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ON THE COVER

THE city of Dallas, Tex., is strategically located to distribute produce to a large area. It is also a convenient way station for the temporary storage of green goods, fruits, etc., in transit from California and the lower Rio Grande Valley to southern and eastern states. These circumstances prompted Fred F. Alford to conceive and erect the record-size twin refrigerated warehouses shown on our front cover. The one-story structures have enough roof area to accommodate seventeen football fields.

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IN THIS ISSUE

THE reputation of Texas in general and Dallas in particular of doing things in bigger and better ways has been enhanced by the erection of the Alford Refrigerated Warehouses. Now nearing completion on a site close to its business section, this super cold-storage plant is not only the world's biggest but also departs from conventional design practices and methods of operation. The important details of the project are given in our leading article.

●

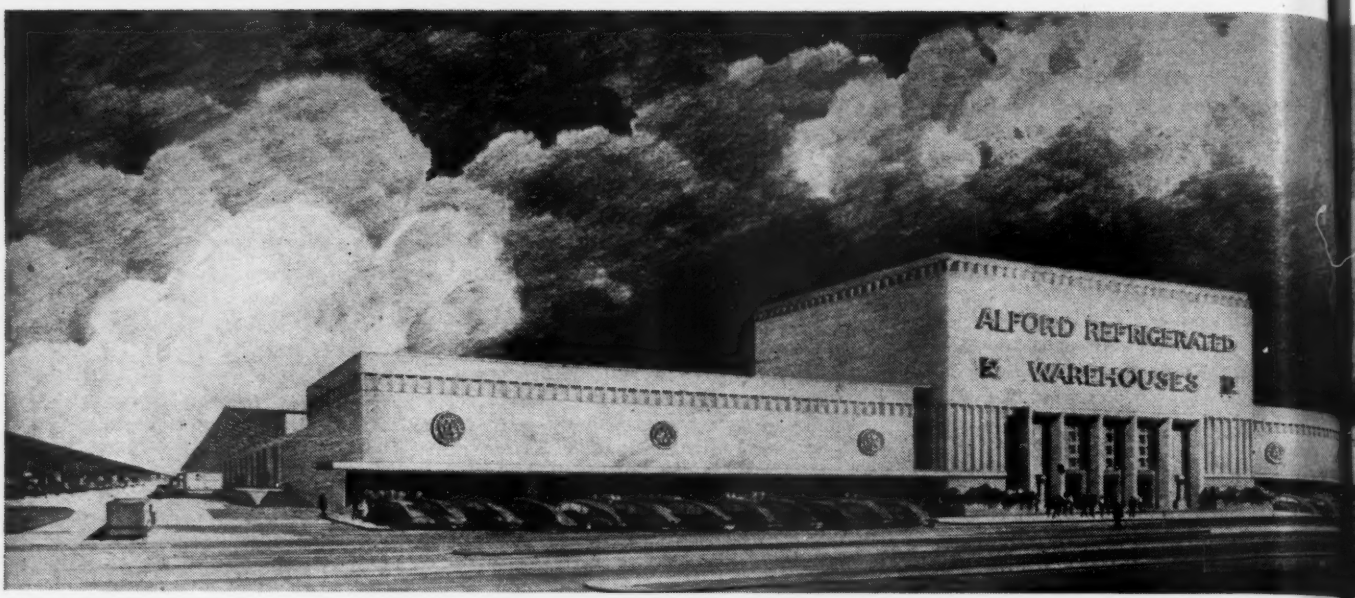
IN AN article on the history and development of the tackle block (page 140) the estimated date of discovery of the wheel—which led to the invention of the tackle block—is given as 3000 B. C. Since the article was written evidence has come to light indicating that the use of the wheel goes even farther back into history. In a clipping that appeared in the *New York Herald Tribune* of May 5, 1949, the National Geographic Society reports that archaeologists working in northeastern Syria have unearthed a vase belonging to a culture existing prior to 4000 B. C. On the vase is a picture of a 2-wheeled chariot carrying a man.

●

AT THE end of the recent conflict France found herself faced with greatly increased demands for electric power. The government therefore initiated a program designed nearly to double, by 1951, the amount of electric energy available before the war. Emphasis was placed on the construction of hydroelectric stations and on the modernization of existing steam plants. The article beginning on page 146 deals with the huge project and what has been done since its inception.

●

THE slogan of Remington Arms Company, Inc., might well be Arms For Industry. The firm produces one of the most unusual products on the market: an industrial gun for use in quarries, open-pit mines, cement mills, etc. It serves to bring down loose rock, to start muck piles flowing, and to remove clinker from revolving kilns. (Page 152)



ARCHITECTURAL STUDY OF OFFICE BUILDING

This structure, now being built, will be in front of the cold-storage building. It will be completely air conditioned and will contain offices, stores, and a 400-seat auditorium with kitchen and display facilities for conventions.

Alford Refrigerated Warehouses

*E. R. Hallowell**

THE big Alford Refrigerated Warehouses, located in the industrial section of Dallas, Tex., are an outstanding example of their kind. They are within easy reach of all parts of the community as well as the country beyond by highways and are served by the Rock Island Lines and, through switching privileges, by all other railroads entering the city. Actual operation of the establishment is now getting underway.

The project consists of two parallel one-story buildings each approximately 1650 feet long and 250 feet wide, including 20-foot canopies extending over continuous 15-foot loading docks along both sides of each structure. One warehouse is refrigerated for cold-storage use and the other is air cooled for dry storage and for semiperishables such as canned goods, sugar, and like commodities. A 100-foot-wide private, paved street for truck traffic separates the buildings, and on the outboard side of each is a double railroad track with switchover points between them, permitting a total of 40 cars to be spotted dockside. At the front of the warehouses is a completely air-conditioned 4-story office building containing about 70,000 square feet of floor space and an auditorium with a seating capacity of 400. The entire plant, including the street, occupies approximately eighteen acres.

The site on which the warehouses stand was cleared, filled, graded where necessary, and rolled and compacted to a uniform load-bearing capacity of about 4000 pounds per square foot. At floor level, the fill was allowed to extend

*Vice-president in charge of engineering, Alford Refrigerated Warehouses.

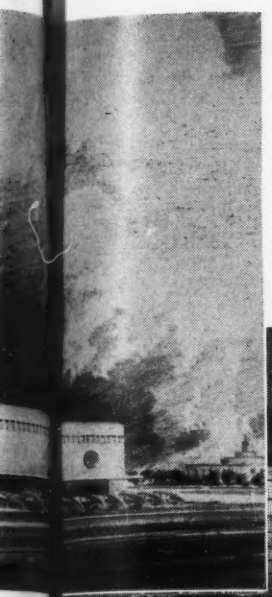
LARGEST OF ITS KIND

THE proportions of the Alford Refrigerated Warehouses call for the use of superlatives. Each of the two buildings is three-tenths of a mile long and 250 feet wide. Double railroad tracks on their outer sides can accommodate 160 cars. The floors of the structures are so extensive that they were laid with highway paving equipment and contain enough concrete to make a 25-foot road 6 miles long.

The cold-storage warehouse provides 7½ million cubic feet of space, while the one for dry storage bulks eight million cubic feet. The next-largest refrigerated storage plant is in New York City and has a capacity of 5½ million cubic feet. Refrigeration required to cool the Dallas establishment would serve 1¼ million family-size deep-freeze units.

From the warehouses, perishables and semiperishables will be distributed throughout a large area radiating from Dallas. It is expected that produce in transit, such as fruits and vegetables from California's Imperial Valley, will be stored there temporarily and then sent on to their ultimate destinations.

Head of the king-size warehouse venture is Fred F. Alford. An accountant by training, he got into the cold-storage business in 1936 when he took over the management of an ailing firm whose books he had audited. He was so successful that the RFC and Dallas bankers financed the $5,250,000 project described in the accompanying article.

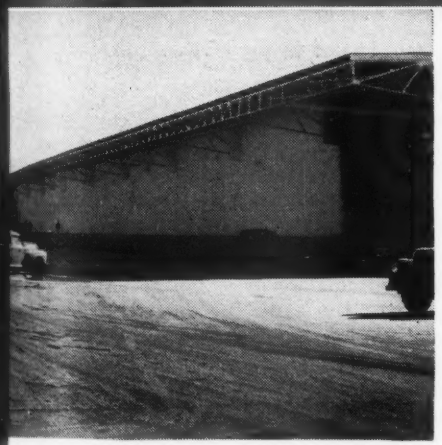


COLD-AIR OUTLETS

Cold air is distributed throughout the buildings by 285 Recold coolers, arranged overhead in clusters of from six to twelve each. Refrigerant piped to these units flows through coils, back of which are fans to blow the cold air out. The coolers are defrosted by running water over them by use of the machine shown at the right. It includes a water tank with a capacity of 500 gallons and a motor-driven pump that can be put in operation by plugging a service cord into an electric outlet. Units are defrosted three at a time, and the water returns to the truck tank.

STORAGE SPACE

Typical section of one of the warehouses, showing how produce on wooden pallets is handled, moved, and stacked by fork lift trucks. There are 24 of these, of which all but four are powered by electric batteries.



PRIVATE STREET

This 100-foot-wide thoroughfare runs the full length of and between the warehouses. The picture shows loading docks for trucks protected by roof extensions or canopies.

somewhat beyond the limits of the buildings, and a trench 18 inches wide and averaging 8 feet deep was dug around the perimeter of each warehouse with a trenching machine. Reinforcing steel, tied in mats, was set upright in the trench, which was then filled with concrete by a self-propelled mixer. After the concrete had set, the earth was scraped away on the outer side down to road and track level, thus forming the dock walls without the use of wooden forms. The street and the floors, docks, and column bases for the buildings were next poured with regular road-paving machinery. The column bases are 18 inches thick, reinforced, and placed at floor level. Floors and docks are 6 inches, and the street 7 inches. By pouring the floor first, it was possible not only to effect savings through the use of power equipment but also to establish a smooth working surface for the erection of the warehouses.

The steel framework consists of columns on 55-foot centers across and 50-foot centers lengthwise of the buildings. Prefabricated steel trusses connect the columns and form a grid on which rest steel bar joists which, in turn, support the roof deck. All field work was bolted. No riveting was done on the job. A 2x2-inch wood nailer strip was fastened to the top of each bar joist to facilitate laying the roof and to serve as an insulation break in the refrigerated sections. The bar joists were spaced on 30-inch centers. Because of the length of the warehouses, each is divided transversely into six sections, or actually six separate buildings, by double columns and trusses. Expansion joints in the roof decking and walls allow for expansion and contraction due to temperature changes.

The roof deck is of concrete and was applied by the Gunite process, which involves the use of a "gun," a double hopper held under air pressure, and a feeding mechanism. Dry sand and cement is put in the hopper, fed through a hose to the nozzle where water is introduced, and the mixture is then sprayed onto the surface to be covered, in this case on "Steeltex," a reinforcing wire mesh with a paper backing, that was stretched across the tops of the bar joists. The resultant concrete is extremely dense and strong because it is placed under pressure and a minimum amount of water is required.

The process is a continuous one—one hopper of the gun may be charged while the other is in service. Hose lengths up to 200 feet may be used and a large area gunited without shifting the equipment. Furthermore, since all mixing and mechanical movement of material are done at ground level considerable savings are effected. The roof deck was built up to a thickness of 1 ½ inches. After priming the concrete, it was covered with a single layer of 15-pound felt laid in hot asphalt, and this was followed by two layers of 0.004-inch-thick embossed aluminum also laid in hot asphalt. The top

was not flooded—the bright surface was left exposed to reflect heat.

All building walls, exterior and interior, are constructed of 10-inch steel studs, similar to the bar joists, set vertically on 5-foot centers. Wooden 1x4-inch strips were fastened horizontally to the studs, and to the strips, in turn, was nailed paper-backed wire mesh to which Gunite was applied to a thickness of about 1¼ inches. This wall section was paralleled by a similar one, leaving a space of approximately 12 inches, which was filled with insulation. As a finishing coat, a very thin layer of white sand and white Portland cement was blown on the walls.

Both structures are insulated with shredded redwood bark, which has two advantages: low first cost and desirable insulating properties. It was blown into the space between the wall sections, completely filling them and embedding the bar joists in the ceiling. Aluminum sheets about 30 inches wide and 10 feet long, with corrugations running crosswise, were placed between the bar joists. They rested on the bottom angles of the latter and formed a ceiling approximately 12 inches below the roof decking. This space also was filled with redwood bark by blowers.

The cold-storage warehouse has approximately 7½ million cubic feet of refrigerated space and is maintained at a temperature ranging from minus 10° to plus 40°F. The rooms vary in size, the largest having a volume of more than one million cubic feet. Freezer-storage commodities include frozen eggs, fruits, and vegetables, meats, fish, dairy products, etc., while cooler commodities include edible nuts, dairy products, shell eggs, vegetable oils, syrups, etc. All cold-storage vaults are equipped with swinging insulated doors operated automatically by pneumatic openers through the medium of electric eyes. Freezers have double doors with an air lock between to prevent loss of cold air, while coolers have but one. All rooms have duplicate sets, one for traffic entering and the other for traffic leaving. Products are handled with mechanized equipment, which is necessary for efficient operation.

Cooling of all vaults is accomplished with blower-type units. A considerable amount of investigating was done to determine the type best suited for the purpose, and this resulted in the selection of small unit coolers. These are mounted near the ceiling in groups or clusters, an arrangement that assures excellent cold-air distribution without the use of ducts. Not only is a saving effected through the elimination of ductwork but fan horsepower also is effectively reduced. The high ceilings (26 feet) lend themselves well to this type of installation.

Defrosting of the coolers is done with water—with a pump and tank truck. The latter is towed to a group, the pump discharge is connected to a header leading to the tops of the units, and the water is pumped into a pan with a series of small holes. Flowing down over the coils in large quantity, the water melts the accumulation of ice and frost and returns to the tank by way of a drain header. Passage of the water over the units is rapid, and there is no freezing in the lines. All blower coils have a large surface area and have been sized to operate on a small temperature difference between the refrigerant and the room atmosphere.

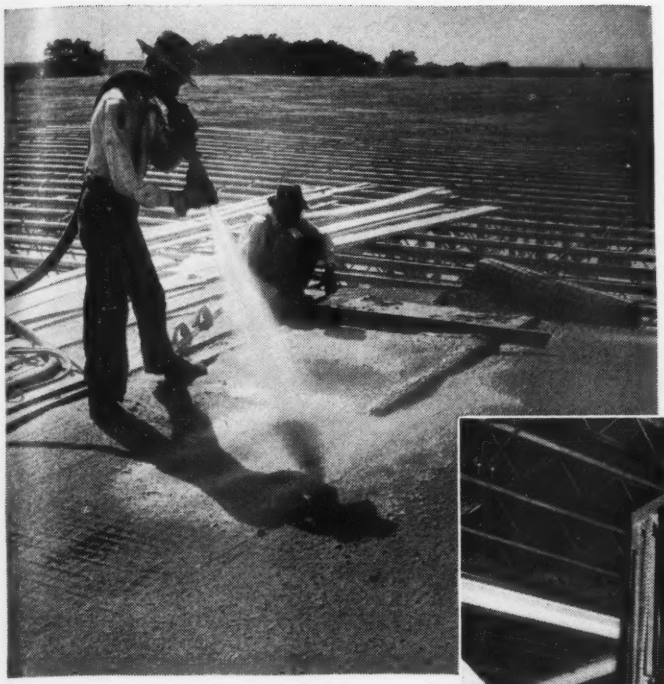
Direct expansion of ammonia is depended upon in all freezers and most coolers. A few of the cooler rooms are equipped for cold-brine refrigeration and will be used for the storage of perishables where an ammonia leak might cause damage. Temperatures in the vaults cooled by direct expansion are regulated by automatic back-pressure valves which automatically control the ammonia pressure in the coils, thus maintaining coil temperatures in accordance with room requirements. Brine flow is controlled by motor-driven valves operated by a thermostat.

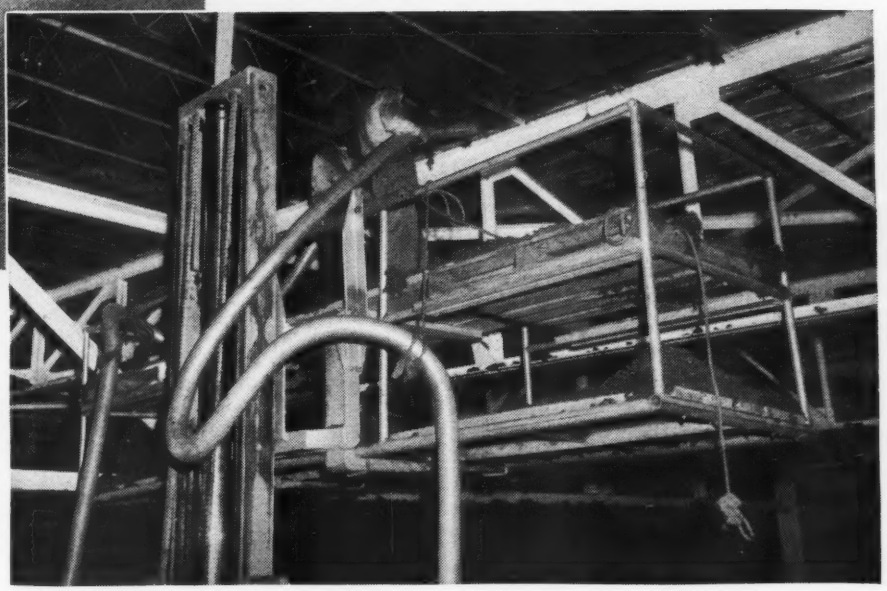
STEEL FRAMEWORK

Concrete floors were poured first, the big area involved making it economical to use conventional highway-paving equipment. It was not unusual to lay a 25-foot strip the full building length of 1650 feet in a day. With the floors in place, the even surfaces simplified further construction. Steel columns, trusses, and bar joists were erected, as shown, and then walls and roof decks were formed by the "Gunite" process.

FORMING LOADING-DOCK WALL

The 18-acre construction site was first filled in, leveled, and compacted by rolling to support an estimated load of 4000 pounds per square foot. The finished surface was at the warehouse floor level, and the fill was carried out beyond the limits of the building area. The retaining walls at the ends of the structures and the dock walls at the sides were then formed by pouring concrete in an 18-inch-wide, 8-foot-deep trench extending around the perimeters of the two buildings. The picture shows a trencher working in the background and a road-paving machine pouring concrete in the foreground. The reinforcing bars projecting above the top of the wall were bent over and embedded in the concrete floor that was laid later. After the concrete had set, the earth fill at the right was removed. By this procedure, satisfactory walls were reared without the use of forms.





BLOWING CONCRETE AND INSULATION

Two of the principal uses of compressed air in the building of the warehouses are illustrated here. At the left, Gunite is being applied to form the roof deck. It was shot against wire mesh with a paper backing to an average thickness of 1½ inches. After a little experience, workmen covered 400-500 square feet per hour. Materials and mixing equipment were on the floor below, and the product was delivered through hose lines up to 200 feet long. The other view shows insulation being blown through a 4-inch hose into the 12-inch space between the corrugated aluminum ceiling and the roof. Shredded redwood bark was selected for the purpose because it is rot resistant, rodent repellent, and does not absorb moisture. The men are working from a scaffold made of piping and mounted on a lift truck. Use of these roving units virtually eliminated the need of erecting conventional scaffolding for construction purposes.

The dry-storage building has approximately eight million cubic feet of usable space and, as previously mentioned, is divided into six main vaults with large steel sliding doors for fast traffic flow. All rooms are equipped with air-conditioning units that use chilled water for cooling in summer and hot water for heating in winter, maintaining a temperature of 65-70°F. This warehouse is designed for the storage of products that keep better if not exposed to excessively high or low temperatures.

The engine room is located at the center of the cold-storage building and serves both warehouses and the office building. Because Dallas is in an area where there is an abundance of natural gas, all compressors are driven by natural-gas engines, and electric current for lighting and auxiliary power is generated by the same means. The electric plant consists of three 250-kw., 6-cycle, 3-phase, 480-volt generators direct-driven by Ingersoll-Rand PVG, 8-cylinder gas engines operating at a speed of 400 rpm. and rated at 375 hp. each. The main switchboard is provided with automatic synchronizers for the generators, reverse-current relays, and the necessary meters and controls. Engine speed is controlled from that switchboard, adjacent to which are panels carrying the main distribution circuit breakers and another with a tachometer for checking compressor speeds, with indicator lights for all pumps and cooling-tower fans, and with time totalizers that give the hours operated by each main engine. Current is transmitted throughout the plant at 480 volts and stepped down where needed by small distribution transformers. Wiring inside the rooms is of open-knob-and-tube construction to minimize troubles through moisture condensation. External and office wiring is in conduits.

Ammonia serves as the prime refrigerant and was selected for a number of reasons, namely: first cost is relatively low, efficiency is high, gas lines are not excessively large, and little difficulty is experienced with moisture and oil. About 900 tons of refrigerating capacity is installed. The four main compressor units are Ingersoll-Rand XVG machines. They are 4-cycle, V-type natural-gas engines with horizontal, double-acting ammonia cylinders bolted to the crankcase and driven directly from the main-engine crankshaft. Two of the compressors have 8-cylinder, 300-hp. engines driving four ammonia cylinders; the other two have 6-cylinder, 225-hp. engines driving three ammonia cylinders.

Four suction pressures are maintained on the ammonia system. Two-stage compression is used for the lowest suction of 0 psi., gauge. Three 15-inch-bore cylinders handle the low-pressure ammonia gas and compress it to 25 psig. An intercooler removes the heat of compression and also cools liquid ammonia from the ammonia receiver. Seven 9-inch cylinders receive gas at 25 psig. from the low-pressure cylinders and also from the brine cooler and cooler vaults and discharge at 185 psig. into the ammonia condensers. Two 9-inch cylinders receive gas at 20 psig. from the ice-making plant, and one cylinder receives gas at 50 psig. from the water chiller.

High suction-pressure cylinders are interconnected and provided with clearance pockets so that the capacity may be controlled to meet various pressure requirements. All cylinders have a 12-inch stroke. Both ammonia-cylinder inlets and outlets are equipped with large surge drums to reduce pulsation, and by-pass valves and safety relief valves are installed between suction and discharge. Safety devices include low-oil-pressure cutouts and high-water-temperature and overspeed cutouts for the engines. High-pressure cutouts for the ammonia cylinders also are interconnected in the engine circuit.

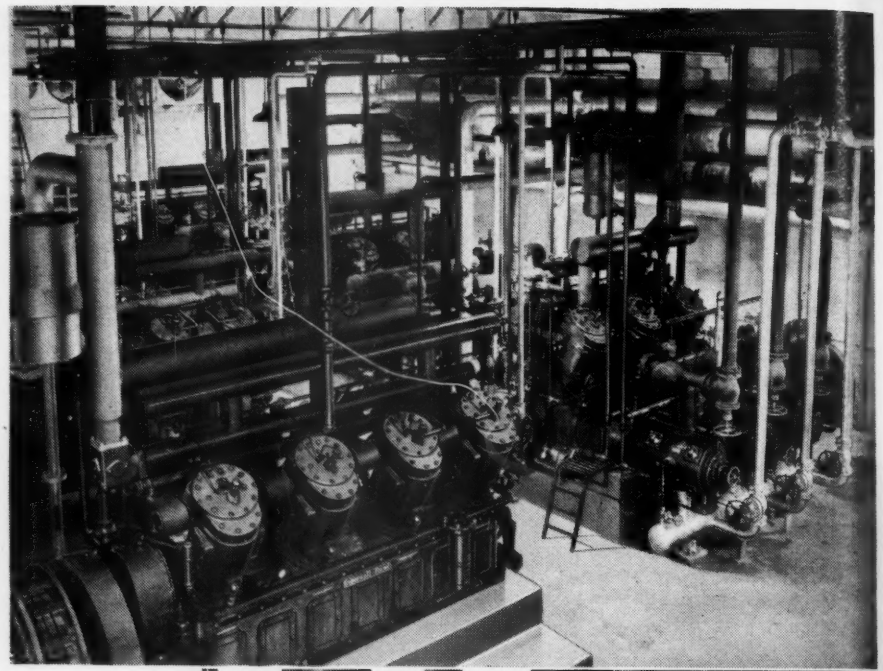
All engines are cooled by an indirect system of four heat exchangers mounted in parallel. Water for the engine jackets flows to two headers: one feeds the suction of two electric-driven pumps which supply water to the XVG compressors and the other delivers directly to the PVG engines which have their own built-in pumps. All water is returned through a common header. During the winter months the return water is by-passed through the air-conditioning system and used for heating the dry-storage warehouse and the office building.

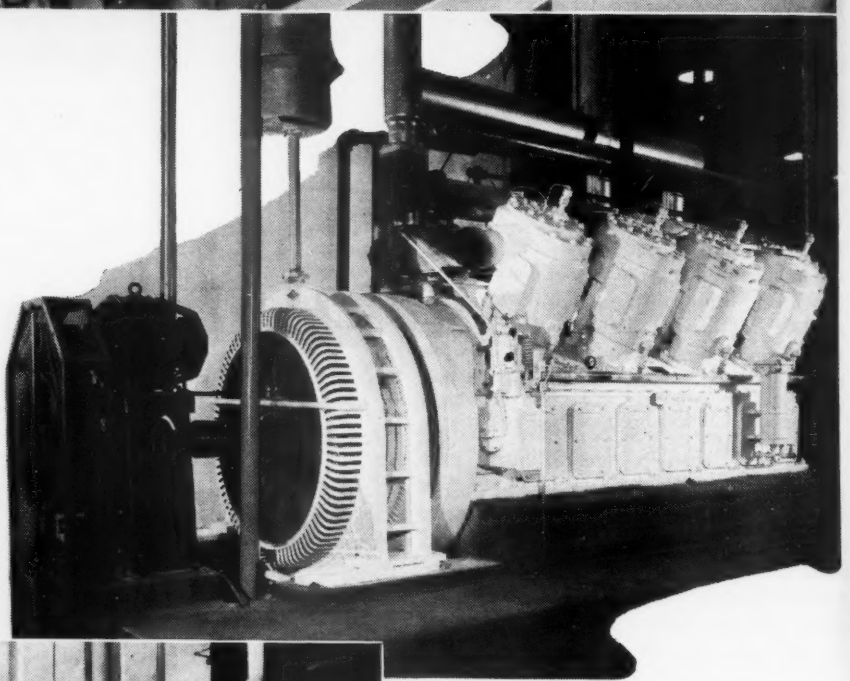
There are nine horizontal multipass shell-and-tube ammonia condensers each with 1000 square feet of surface. These are racked three high and three wide and beneath them are two receivers each 36 inches in diameter and 18 feet long. Ammonia intercoolers and oil separators are mounted between the condensers and the engine-room wall.

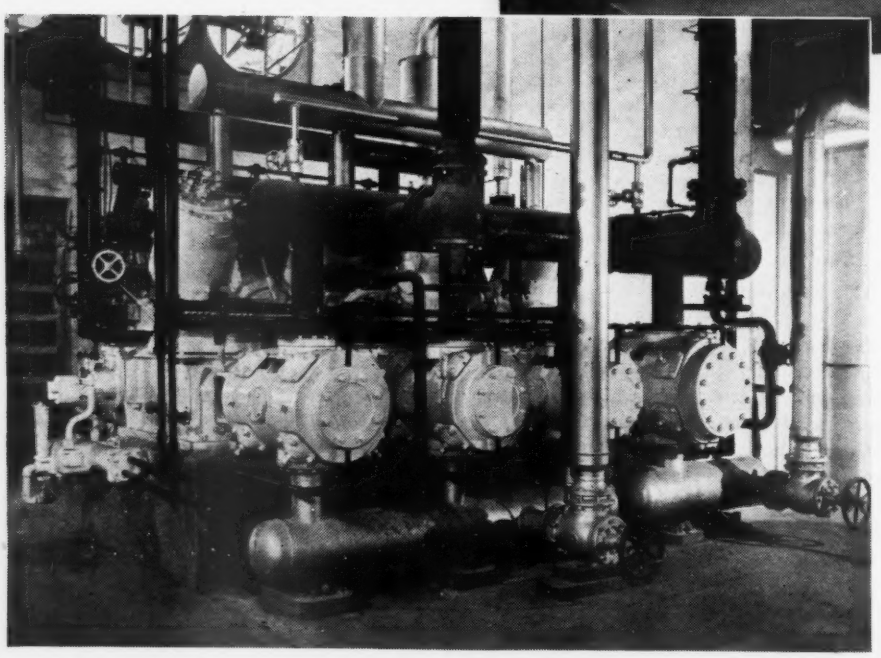
Three 9x9-inch vertical, single-acting ammonia compressors belt driven by small high-speed natural-gas engines serve as standbys and to meet air-conditioning loads during the summer. Two 30-ton-capacity "Pak-Ice" units also are installed in the engine room for the manufacture of ice for car icing. These machines are automatic in their operation. Brine and water are cooled with shell-and-tube coolers. The shells are flooded with ammonia, and all coolers are equipped with back-pressure regulators to prevent too low an ammonia temperature.

A central temperature-indicating system is in use. This consists of resistance-type thermometers mounted in the different cold-storage rooms and of a central control board in the engine-room office. By depressing keys, the temperature in any cold-storage space may be read.

Across the tracks from the engine room are two cooling towers with the pump house inbetween. The tower for the ammonia condensers is of the induced-draft type with two fans and a cooling capacity of 4500 gpm., while the engine intercooler tower is of the forced-draft type and has a single fan. The capacity of the latter tower is 1000 gpm. The pump-house installation totals nine pumps: four and one spare for the condenser tower, two and one spare for the intercooler tower, and a pump serving the ammonia-compressor jackets. Water is carried from and returned to the





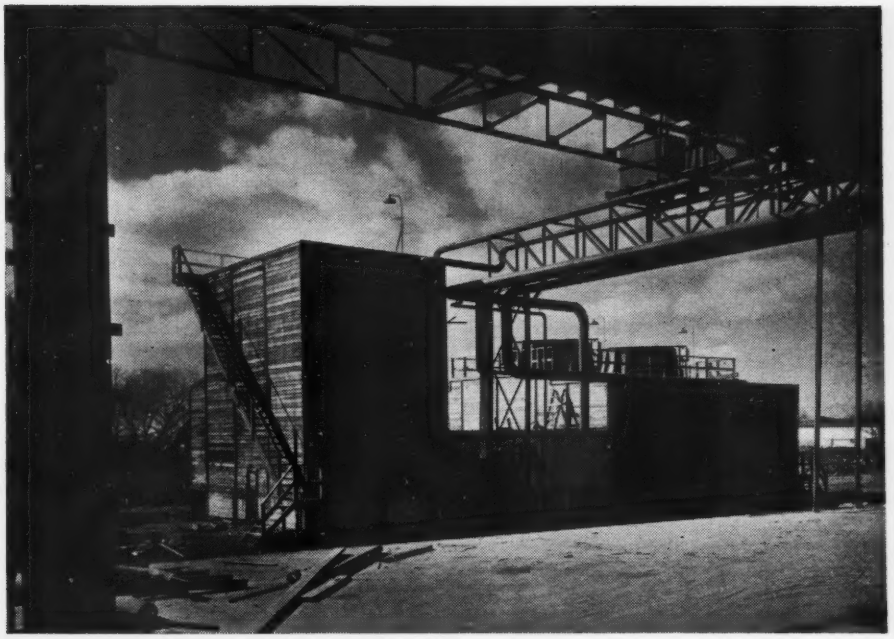


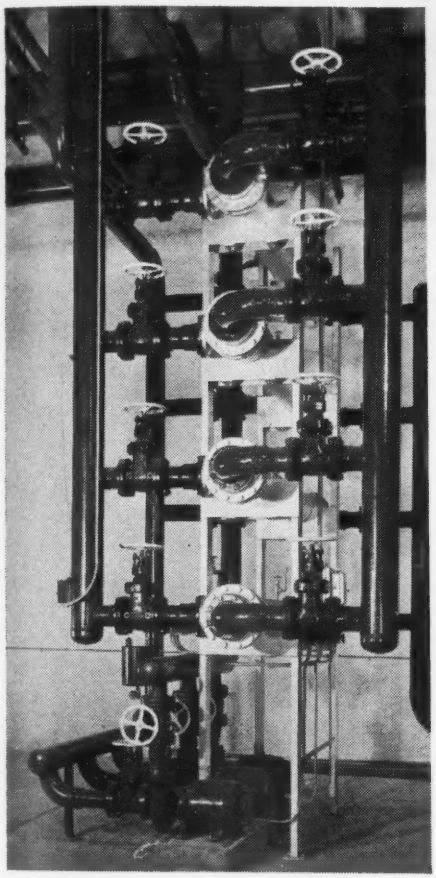
AMMONIA COMPRESSORS AND GENERATORS

Because natural gas is plentiful in the area, it is used for all power purposes in the warehouses. Their combined refrigerating capacity is 900 tons, most of which is provided by four main ammonia compressors. These consist of Ingersoll-Rand Type XVG gas engines direct connected to compression cylinders. Two of the engines are 8-cylinder, 300-hp. units and two 6-cylinder, 225-hp. units. The number and sizes of the compression cylinders vary with the conditions they are designed to meet. Power for the establishment is supplied by three generator sets, each consisting of an Ingersoll-Rand Type PVG 8-cylinder, 375-hp. gas engine direct connected to an Electric Machinery Manufacturing Company 250-kw., 480-volt generator. Pictures from top to bottom show the compressors and generating units, a single generator set, and a 300-hp. compressor with four compression cylinders.

COOLING TOWERS AND HEAT EXCHANGERS

Raw water for condensing ammonia gas and for cooling the water that is circulated through the gas-engine cylinder jackets is itself cooled by passing it through an induced-draft and a forced-draft tower, respectively (right). The pipes through which the water flows from and back to the pump house between the two towers form the upper and lower members of a truss bridge, as shown. During each circuit, the engine cooling water passes through an Ingersoll-Rand intercooler (bottom) where it comes in contact with tubes through which the water from the cooling tower flows.





pump house by way of a bridge made up of the water pipes themselves, with struts as bracing. In the rear of the pump house is a water softener, and all make-up water for the plant is treated there. A corrosion inhibitor also is added, as needed.

The main ammonia headers extend the full length of the cold-storage building. Because they are so long, bellows-type expansion joints were placed at intervals to take care of expansion and contraction due to temperature changes. Exposed cold lines are insulated. All piping in the engine room is color coded and run overhead. Ammonia headers are on one side of the room; electrical conduits are on the opposite side; and water, air, and gas lines are in the middle.

A steel bridge spans the street between the two warehouses at roof level and serves to carry chilled-water, power, and telephone lines from one structure to the other. Chilled-water pipes are run over the roof from the engine room to the office building for air-conditioning purposes.

The warehouses have been designed with a view towards mechanized operation. Both are of one-story construction to eliminate bottlenecks such as elevators and narrow corridors. Docks along both sides of the buildings are wide for the fast movement of incoming or outgoing commodities. Cold-storage vaults open on to work spaces that run through the warehouse and lead to the docks by way of 20-foot-wide doors.

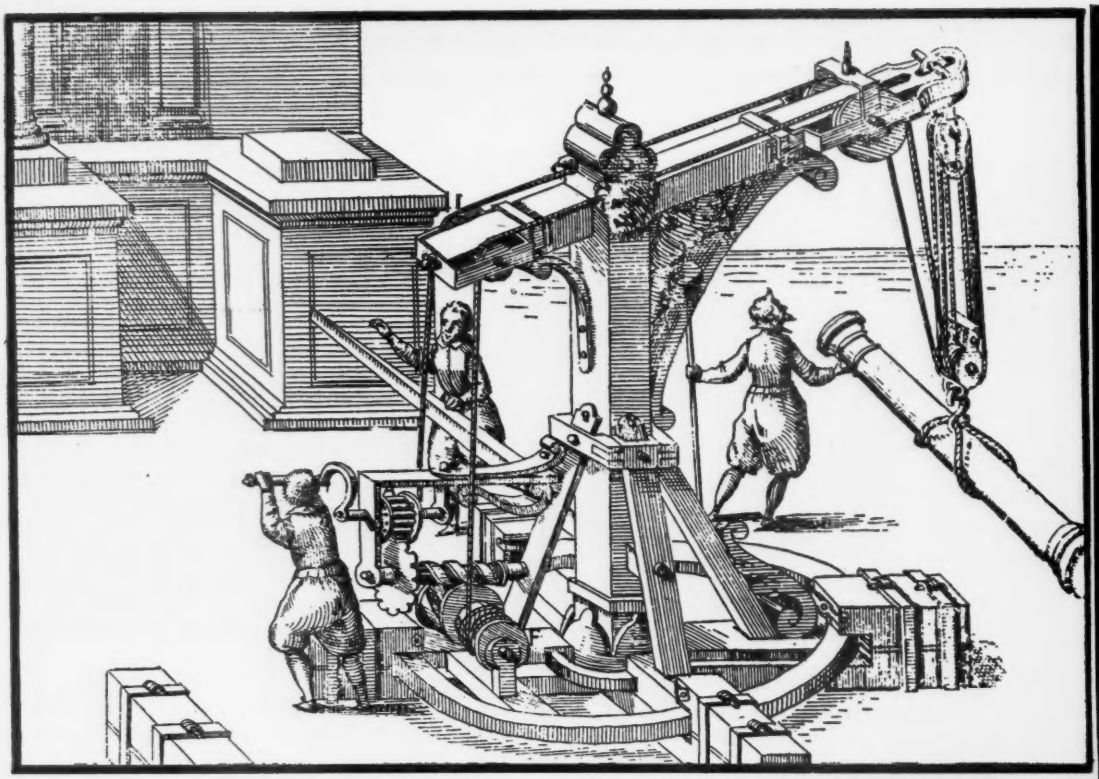
Fork lift trucks are used well-nigh exclusively in both buildings for handling merchandise. Upon arrival, the products are placed on pallets right in the cars, carried into the rooms by the trucks, and stacked. This method has several advantages. In cold storage, little work is done in the vaults except by the fork operators, who can dress warmly because they do not have to move about on foot. All palletizing is done outside where temperatures are moderate, and commodities can be stacked higher with less effort and cost than they can by hand. Operations are expedited because tremendous quantities of merchandise can be handled in a short time.

Most of the fork lift trucks are battery powered. Cold-storage rooms are of tight construction, and the use of gasoline motors in such spaces might prove hazardous. Furthermore, maintenance of battery-run vehicles is low, and where hauls are not long they operate with a minimum of trouble. For service in the dry-storage warehouse, where long hauls may be necessary, several gasoline-engine fork trucks and a number of trailers are available. The pallets are loaded on the trailers which are pulled to their destinations, where the fork trucks pick up the loads and stack them. Batteries are charged in the trucks at night ready for the next day. This work, together with battery upkeep, is done in the engine room.

An interesting side light in connection with the fork trucks is the use to which they were put in constructing the warehouses. They were equipped with scoops to handle sand, cement, and concrete mix for the guniting operations. Material cars were unloaded with them. Scaffolds of iron pipe were built to fit the forks, and these roving, highly maneuverable units served as platforms for all kinds of jobs from hanging pipe to guniting. They saved literally thousands of man-hours.

A goodly proportion of the commodities entering and leaving the warehouses is in carload lots. This is especially true of transit items which are held in storage for a period and then shipped to their ultimate destinations. The office building is to be occupied primarily by representatives of companies having merchandise in storage, by brokers, and the like. It is windowless and lighted throughout by fluorescent lamps. An automatic elevator serves the third and fourth floors. Exhibition rooms are available, and the auditorium will be outfitted with kitchen and display facilities for food-industry conventions, for equipment manufacturers, etc.

Because of space limitations, it is possible to give only an over-all picture of the huge plant and to detail those construction features that are believed to be unique and interesting. The finished parts of the warehouses are now in operation and indicate that the design is sound, for the results achieved to date have been excellent.



THREE LIONS PHOTO

SEVENTEENTH-CENTURY CRANE

This sketch, from the book "Theatrum Machinarum" published in 1612, shows a crane at work setting up a heavy column. The gears between the crank handle and the double hoisting drum greatly increased the power applied by the operator, while the block-and-tackle arrangement multiplied it still more. Consequently, the device must have provided what was then considered a powerful lifting force. By pushing the beam projecting from the far side of the crane, the latter could be rotated on its base to move the load laterally as well as vertically.

Tackle Blocks— Past and Present

Madesco Tackle Block Company Turns Out Many Varieties of a Labor-Lightening Device That Probably Has Been Known for Some Two Thousand Years

Walter P. Gillingham

ONE of the chief reasons for man's rise to supremacy over all other members of the animal kingdom was his ability to invent devices that would multiply his strength. So long as the weight he could lift or transport was limited by his own energy, prehistoric man was little better off than the wild creatures about him.

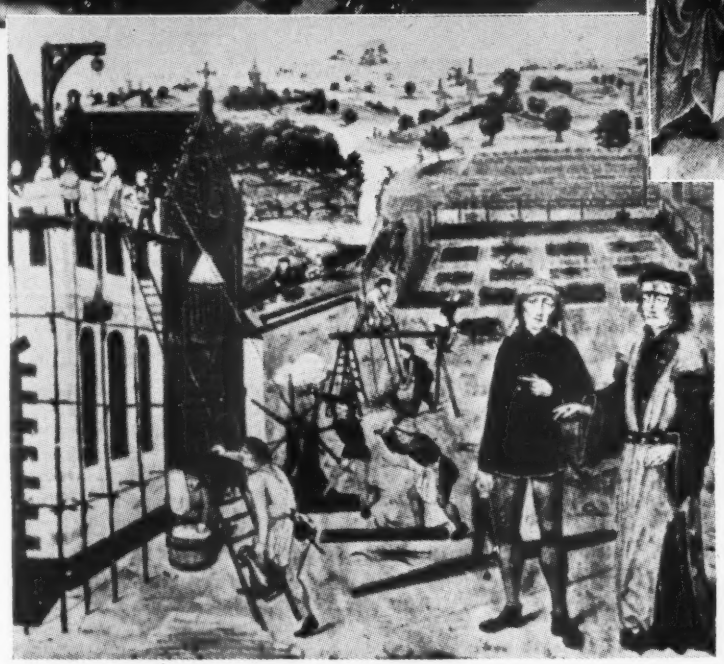
Scientists tell us that the four basic tools upon which our present complex civilization is based are the lever, the inclined plane, the wedge, and the wheel. Of these, the wheel was the last to be discovered. Its adoption led to the development of one of mankind's most important labor savers—the tackle block—which has been known and used for more than 2000 years and which is an essential part of present-day cranes, derricks, elevators, and other lifting devices.

Tackle blocks make it possible to change, at will, the direction of an applied force and to multiply the effect exerted by that force. The manner in which they do this is so well known today that nearly every high-school student can calculate the mechanical advantage gained by the use of a particular block-and-tackle system. Nevertheless, thousands of years were to elapse before our ancestors grasped the principles of the wheel and, in turn, of the pulley.

Most historians believe that the wheel originated in southwestern Asia around 3000 B. C., and that the practice of using logs as rollers to shift heavy objects was the chief contributing factor in its discovery. Whatever brought it

TACKLE BLOCKS

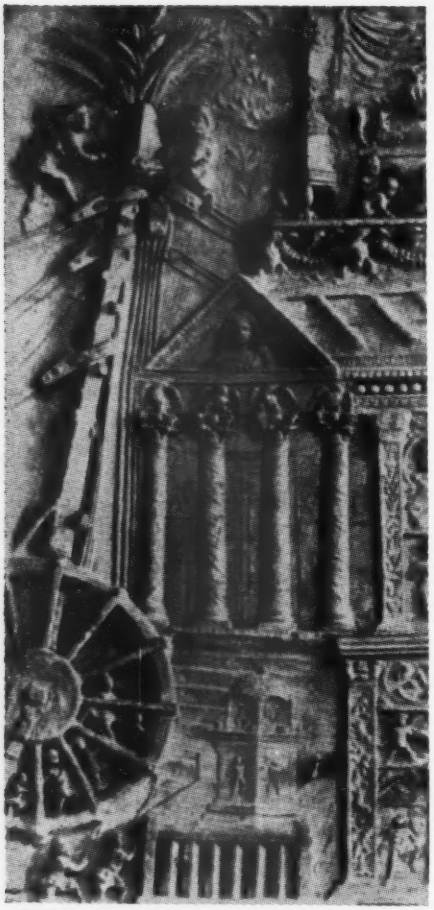
Blocks of many kinds and sizes awaiting shipment at the Madesco plant. Shown against a background of wooden units are a few of the different all-metal types. In his right hand, the kneeling employee is holding a heavy steel snatch block designed for use with wire rope in hauling operations. The large oval-shaped one on his right side is a heavy hoisting block for maritime service. In his left hand is an automatically lubricated wire-rope block made for dragline work and for skidding operations in the lumber industry. Next to it are a large snatch block and a hoisting block both developed solely for oil-field use.



THREE LIONS PHOTOS

EARLY BUILDING PRACTICES

These illustrations from fifteenth century manuscripts depict some of the hoisting equipment in use at that time. The view at the left is from a Flemish source and shows a building in course of construction. At the top of the wall is a gallowslike bracket carrying a single pulley. The load is being raised with a hoisting crab having a trunnion but no wheel. The masterbuilder, obviously accompanied by a person of considerable importance, is carrying a huge plumb bob. The other picture appeared in a French manuscript of 1423 and is an artist's conception of the building of the Tower of Babel. The hoisting tackle shown consists of a winding crab with a wheel and two handles and of a double rope running up over a pulley whose trunnions turn in striding posts. According to the Book of Genesis, all peoples once spoke the same language. After the flood, when they attempted to erect a tower that would reach to heaven, angry angels confounded their speech so that each man spoke a different tongue. Unable to communicate, they abandoned the project and separated to found the different races of the earth.



THREE LIONS PHOTO

ROMAN HOISTING DEVICE

Shown here is perhaps the earliest evidence of man's use of block-and-tackle. Taken from the relief on a tomb built in 40 B. C. at Centocelle, near Rome, it was named "polyspaston," which means compound pulley. The hoisting drum at the foot of the mast is being turned by a treadmill run by several workmen, while two others are stationed at the top of the mast. Heavy building stones were raised by means of this device.

about, it is certain that the invention of the wheel was a significant advance, because by substituting a small amount of rolling friction for a large amount of sliding friction the weight moved by the same applied force could be increased many times. Another advantage was the ease and rapidity with which men and materials could be transported from one place to another.

Having grasped that the wheel would benefit him greatly if he used it to move heavy objects in a horizontal direction, it was only natural that man should make it help him lift loads in a vertical plane. By mounting the axle in a fixed position on a supporting wall or framework and by running a rope up over the wheel, attaching one end to the object to be raised, and pulling on the free end, he found that he could lift a weight with very little loss of power due to friction. In order to keep the rope from slipping off the wheel, he either encased the latter in a boxlike frame or grooved the rim.

Thus the first pulley was born. This simple device, which is still used in essentially the same form, offered him no mechanical advantage; that is, the applied force was not multiplied. However, it did allow changing from an upward- to the more convenient downward-pulling force. Further, it could hoist objects to heights far beyond those a man could reach.

That the ancient Egyptians knew of the pulley has been established. The remains of one fashioned by them have been found and are now in a museum at Leyden, Holland. The sides were of *athul*, or tamarisk wood, and the roller of fir. Pieces of rope made of *leef*, fibers of the date palm, were unearthed with the pulley. The date of these relics is unknown, as is the purpose for which the device was used, although it is thought to have been contrived for drawing water from a well.

What is perhaps the earliest evidence of man's use of the single, fixed pulley is that discovered in the ruins of the palace of Shalmaneser II, who ruled as king of Assyria from 858-823 B. C. Among the rubble was an obelisk of black marble upon which were carved the annals of his reign. One of the scenes depicts a warrior filling a bucket from a small stream flowing near the base of a stone wall. Fastened to the bucket is a line that runs up and around a single pulley mounted on a battle tower on top of the structure, an arrangement that permitted hoisting water to those stationed in the tower.

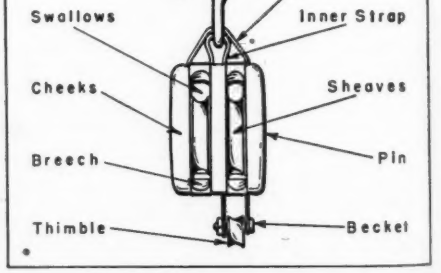
From the single, fixed pulley it was but a step to the pulley block. By encasing the wheel in a light, U-shaped or boxlike frame, man found that it could be divorced from the heavy scaffolding or wall that served to support it. Simply by tying a rope to the frame, the unit could be secured wherever it was needed and just as quickly moved from place to place when necessary.

Now that man had learned to alter the direction of an applied force by means of a pulley, it remained for him to discover that he could lift a much greater weight by combining two or more than he could with but one. This came about when someone thought of attaching a pulley to the object to be raised, running a rope from the framework or axle of the top pulley down and around the bottom one and back up and over the upper one, and then hoisting the load by pulling on the free end of the line. As the object was supported by two ropes the weight was divided equally between them—each carried only half the load. Consequently, only half the effort needed for a single pulley sufficed to raise the object which, however, moved at only half the speed. By combining three, four, or more pulleys, a further decrease in lifting effort was secured with a corresponding increase in hoisting time.

The idea of combining pulleys to gain a mechanical advantage is generally attributed to Archimedes, the great Greek mathematician who lived from 287-212 B. C. Archimedes was one of the pioneers in the science of mechanics and invented many ingenious devices to prove his theories. Contending that a small force properly applied would move a great weight, he made his classic remark, "Give me a place to stand and I will move the earth." When challenged by Hiero II, king of Syracuse, to prove this statement, he is said to have constructed a contrivance by which Hiero, unaided, was able to move a large, heavily laden ship. Accounts differ as to the means he employed, so it is not known whether tackle blocks played a part.

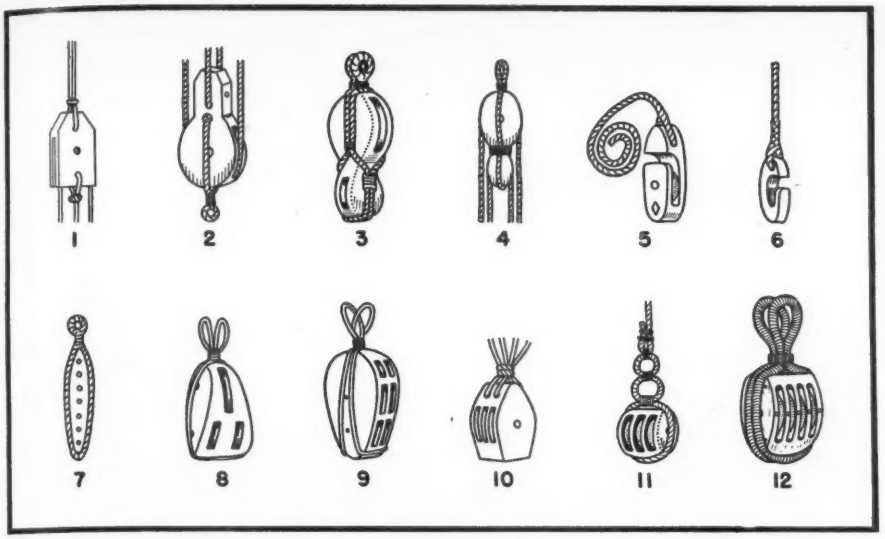
Archimedes did, however, devise many things that made use of the single pulley. When Syracuse was besieged in 215 B. C. by the Roman general Marcellus, Archimedes built engines of war that terrified the Roman soldiers, dealt havoc with their shipping, and delayed the fall of the city for three years. Chief among those weapons was the catapult, which hurled stones, darts, and other missiles at the enemy. Pulleys fastened to the arms of the catapults enabled the warriors to draw them back with the aid of ropes and windlasses for reloading and release.

The first application of block-and-tackle of which there is knowledge was made during the time of the Roman Empire. The Romans, the world's greatest builders of their day, used both single pulleys and tackle blocks for hoisting building materials. For raising large, heavy pieces of stone they fastened several tackle blocks to the top of an upright pole or mast and ran ropes from the blocks to a hoisting drum located at the base of the mast and turned by a treadmill. For smaller loads a single pulley sufficed, and that was mounted on



PARTS OF A TACKLE BLOCK

Many of these names, which are the same for both wooden and all-metal blocks, have descended from early nautical terms. For instance, the word that designates the grooved wheel in a block used to be "shiver." In the seventeenth century it was shortened to "shiv," and now it is "sheave."



EARLY WOODEN BLOCKS USED ON SAILING SHIPS

Sketches from "The Book of Knots," by Clifford W. Ashley (Doubleday, Doran & Company, New York, 1944): 1, Early seventeenth-century block that is representative of one of the earliest-known types. 2, Block of the same period having two sheaves at right angles to each other. It is strapped by a rope passing through a hole between the sheaves. 3, Eighteenth-century block with sheaves at right angles. It is double-strapped. 4, Fiddle block with the sheaves placed one above the other to make it lie flatter against the yard or mast than if they were side by side. 5, Early type snatch block. 6, Swig block. It has no sheaves and resembles a snatch block. 7, "Euphroe block," which had "many holes but no shivers." It was used to extend an awning or other covering. 8, Threefold block of the eighteenth century. 9, Multi-sheave block described in Crescentio's "Nautica Mediterrania" of 1607 as the type used to distribute the strain of running rigging. 10, Earliest method of strapping was to reeve the rope through a hole in the end of the shell, as shown in this sketch of a seventeenth century block. 11, Method of strapping a threefold block as given by Vial du Clairbois in his 1787 "Encyclopedie Methodique Marine." 12, "Heaving-down" or "careening" block. Rigged between the mast and the shore, such blocks were used to turn a ship partly over on one side so as to expose the other for scraping, calking, and other work.

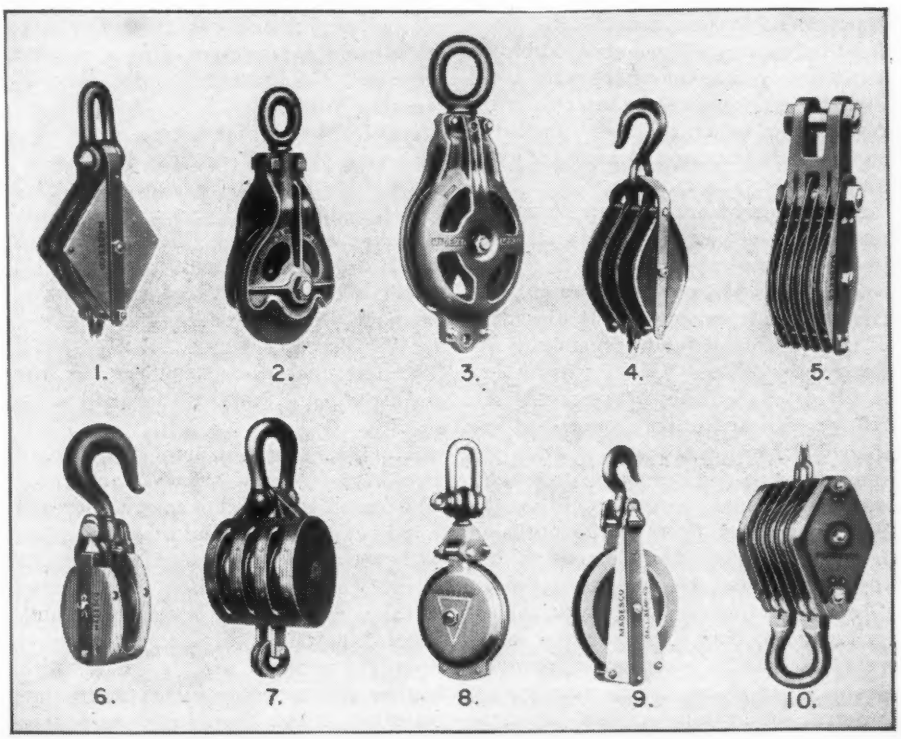
the wall being constructed and carried progressively upward with it.

Until about the fifteenth century the use of lifting tackle was confined mainly to the erection of buildings, and simple forms prevailed. Single pulley blocks were suspended from brackets or from gallowslike arrangements secured atop the framework of the rising structure and served to hoist materials to the men working there. Where loads were to be raised to intermediate levels such as balconies the pulleys were usually mounted on trunnions turning in a pair of striding posts. Ropes were generally wound around windlasses or drums turned by hand cranks or spokes. Frequently two or more were paid out from the same winding device, and the load was attached to the hoisting lines by hooks, rope slings, calipers, and other devices.

Many complicated and weird-looking contrivances were invented in the sixteenth and seventeenth centuries in an effort to increase the power exerted by man to turn the drum. Among these were large wheels driven by ropes or chains, toothed wheels, sprockets, and wooden worm-and-spur gears. Considerable use was also made of multiple pulley blocks, and methods of reeving them were worked out that are still practiced.

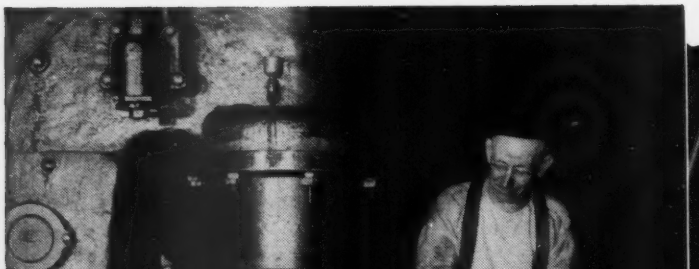
Recognizing the need of faster and better lifting apparatus, engineers turned their attention to the problem at the close of the eighteenth century. The only rope available up to that time was made by hand of hemp and presented difficulties. Where heavy loads had to be handled, the lines were often as much as 6 inches thick and had a short service life, aside from being costly. In 1792, however, a rope-making machine was introduced. That invention was followed by improved methods of manufacturing tackle blocks and, later, of drawing wire rope. All served to lay the foundation for the tackle used on present-day lifting machines and devices.

No history of tackle blocks would be complete without some mention of the part they played in the development of ships. From the first crude vessels of the Egyptians nearly 5000 years ago to the craft of today, tackle has been required to help in steering, hoisting sails, raising anchor, loading and unloading cargo, etc.



MODERN TACKLE BLOCKS

1, A diamond-pattern wire-rope block fitted with a chain shackle. 2, All-steel hollow-type skidder block with a swivel eye used in heavy-duty lumbering. 3, All-steel cargo-hoisting block known as a cargo runner. 4, Maine lumberman's block with three sheaves and a loose hook. 5, Extra-heavy oval fivefold block for marine service. 6, A self-locking manila-rope, wooden "snatch" block so called because its hook can be loosened and swung to one side to permit the block to be attached to any part of a line already in service. 7, Wide-mortise, threefold wooden block with regular shackle for use with manila rope. 8, A malleable-shell, wire-rope snatch block with a swivel eye and shackle. 9, All-aluminum snatch block used for stringing copper and aluminum conducting cable. 10, An extra-heavy plate-extended fivefold block, with side cheek weights and forked shackle. It is the lower or "lead" block for the one shown right above it.



MANUFACTURING TACKLE BLOCKS

In the view at the top-left the workman is forming the eye of a fitting on a drop hammer in which compressed air, supplied by a small motor-driven blower, cushions the impacts. The operator controls the length of the hammer stroke by means of a valve. At the top-right a hook is being fastened into the head of a snatch block with an Ingersoll-Rand Size 8A riveting hammer. Using a Size 504 pneumatic impact wrench, the man directly above is assembling a 6-inch wire-rope snatch block of the self-locking type.

Often the lives of the sailors depended upon the speed and efficiency with which they could alter sail or change course. Small wonder, then, that much of the early history of tackle blocks and ships is closely interwoven.

Just when tackle blocks were first used on shipboard is unknown, but there is little doubt that their appearance there coincided with that on land. Models of Egyptian vessels of about 1600 B. C., placed in tombs to provide departed souls with transportation in the other world, show that there were ropes on the masts for raising yardarms and that they were led through square openings in a framework of wood. That crude contrivance acted as a tackle block. At the time of the Roman Empire, the single fixed pulley was utilized aboard ship for various purposes, among them the hoisting of large stones to the top of a battle tower, from which they were hurled at enemy craft or troops by means of a catapult.

Little is known about the structural features of early ships' tackle, but there is ample proof that it came to be an essential part of a vessel's paraphernalia. Records are in existence of the building of two warships—the *Sovereign* and the *Regent*—by Henry VII of England at the close of the fifteenth century. Although each had a displacement of less than 600 tons, they were of such advanced design and armament that their launching caused a sensation. When the *Sovereign* sailed from Portsmouth on January 29, 1510, the warrant of her voyage included the following items: "Twyne, merling (marlin), ropes, cables, lynes, tacks, lists, toppe-armers, stremers, standards, compasses, ronnyng glasses (sand-glasses for the ship's log), lanterns, shrowdes, shevers of bras (brass sheaves), poleys (pulleys), and other taclyng."

In the United States, shipbuilding started in Philadelphia soon after the arrival of William Penn who, in 1681, wrote that among those already settled in the colony on the Delaware were "Shipwrights, Carpenters, Hewers, Sawyers, Trunnel-Makers, and Joyners." By 1685 ships were being built for West Indian, English, and European merchants—craft that were to become famous for their workmanship and fine material.

In 1718, one James Logan, Philadelphia shipbuilder, wrote that "Almost all the paraphernalia for a ship, such as ropes, sails, iron work, and blocks, can be procured from local craftsmen." He mentioned ropemakers, also a Stephen Beezley, blockmaker. John Reynell, another shipbuilder, listed the following items in his account book for the construction of the *Torrington* in 1728-29: "To Hugh Cordry, blockmaker, for his Bill for Blocks and &c.....£7- 6- 6. To Stephen Beezley, blockmaker, for his Bill for Blocks and &c.....£12- 12- 2." For a second vessel, the *Delaware* he paid "Simon and Stephen Beezley for Blocks and &c.....£24- 16- 2." The latter also made blocks for the *John and Anna* built by Richard Deeble in 1734.

The blocks used on shipboard were of two kinds: "made" and "morticed." The former consisted of several pieces of wood cut separately and fitted together, while the other was chiseled from a single piece. The grooved wheel was either of metal, such as iron or brass, or of wood. Blocks suspended in the rigging were usually strapped with rope or with leather thongs because they were considerably lighter than iron-bound ones and therefore did far less damage to sails through chafing.

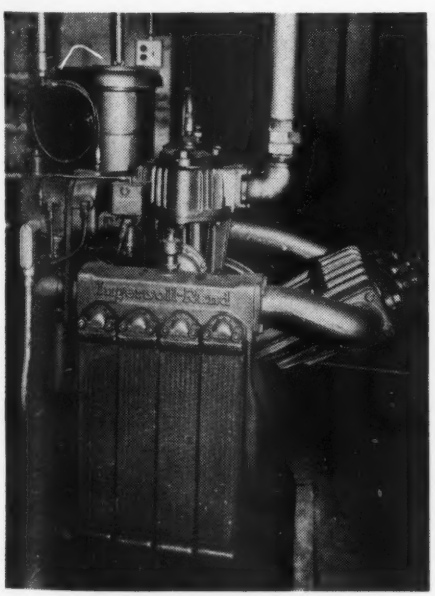
Because early-day sailors were also craftsmen they could, with a few simple tools, fashion almost anything needed for the rigging. Ships' stores usually included quantities of extra sheaves, and any ship's carpenter could, on short notice, turn out tackle blocks comparing

favorably with those made on shore. And any sailor worthy of the name could whip out his jacknife and quickly convert a piece of wood or whalebone into a temporary block.

Tackle blocks have changed little in general design throughout the years, but materials of construction differ considerably. Once wood was the principal material; now metal is largely used. Where sheaves once squeaked on wooden axles greased with animal fat, modern sheaves turn smoothly and quietly on well-lubricated bearings that reduce friction to a minimum. Today, with the exception of a few operations that involve handwork, modern machinery and labor-saving tools have converted the making of tackle blocks into a fast, efficient, and economical procedure.

The principal parts of a modern tackle block are the shell, the sheave, the center pin, straps, and connections. The shell or housing safeguards the sheave from damage and also keeps the rope in place on the sheave. The center pin serves as the axle for the sheave and transmits the load from the rope to the straps and connections. The straps take the load from the center pin and also hold the block together, while the connections permit fastening the block to supports, to objects to be lifted, to ropes, or to other blocks.

Individual blocks are of the single, double, threefold, and more type, depending upon the number of sheaves. The more a block has, the greater the gain in mechanical advantage. However, the factor of sheave friction limits the number that can be used, making more than ten impractical in most cases.



SOURCE OF AIR POWER

Compressed air for operating pneumatic tools in the Madesco plant is supplied by an Ingersoll-Rand Type 40, two-stage, air-cooled compressor discharging at 100 psi. pressure. It is driven by a 25-hp. motor.

For most efficient service, tackle blocks should be used in pairs, and each pair, when properly reeved with rope, becomes a machine—by definition a device—capable of effectually applying force to do work.

Most block-and-tackle hoisting systems consist of an upper block fastened to a support and of a lower one to which the load is attached. The pull is generally applied to the upper one from below. The latter is referred to as the standing or stationary block, and the lower one as the running or movable block. In nautical terminology these become the "fall" and the "loose" or "lead" block, respectively.

The manufacturing operations of the Madesco Tackle Block Company of Easton, Pa., are typical of the manner in which modern tackle blocks are now produced. The present concern, after World War I, took over the business of the Marine Decking & Supply Company, makers of ships' decking material, reorganizing it and changing over to tackle blocks for marine service. Subsequent growth and expansion enabled it to broaden its line and to include a wide variety of blocks for all important fields such as mining, lumbering, construction, oil-field use, and industry generally. The company is a subsidiary of the Nazareth Cement Company and the plant is under the management of E. M. Metzgar.

Blocks turned out at the Madesco plant differ greatly in size, weight, and number of sheaves. Its largest sets of blocks were produced during the last war for the U. S. Army and were, roughly, 4 feet square, weighed 1½ tons each, had ten 24-inch-diameter sheaves, and were tested at the Fritz Laboratory, Lehigh University, to lift safely a load of 400,000 pounds. The smallest is a block weighing only one pound and having a single 3-inch sheave. Between these wide extremes are innumerable sizes and shapes.

Approximately 60 percent of the output is of all-metal construction, with shells of steel plates, cast steel, malleable iron, or aluminum. The remainder of the blocks have wooden shells. Sheaves are cast of iron, steel, or aluminum, or are drop-forged of steel. Sheave pins are machined from high-tensile steel and mounted in graphite-bronze bushings or in sealed roller or ball bearings. Straps are made of steel, and external fittings such as hooks, shackles, eyebolts, etc., are drop-forged of steel.

Iron and steel arrive at the plant in the form of bars, strips, bands, and plates. After being cut to size, some of the material is sent to the forging department where the pieces are heated in oil-burning furnaces to the correct temperature. Next they are placed in drop hammers and forged into shackles, hooks, and other fittings. Parts such as steel shell plates, straps, beckets, etc., are fabricated in the machine shop, ready for assembly.

Sides, center pieces, and spacers of the shells for wooden blocks are made of strips of ash, maple, or other hardwood and planed to a smooth finish. Grooves to accommodate the straps are then cut, holes are drilled, and the several pieces assembled and fastened together with rivets. The rectangular-shaped product goes to a special shaper machine that gives it the desired oval or round shape. Each shell is dipped twice into a commerical grade of varnish in order to preserve the wood and to make it moisture-proof.

The assembling operations at Madesco are typical of the manner in which air power can effect economies. The company recently installed a compressor and several air tools, and the results obtained with them have been gratifying. For example, formed and heated hooks were formerly fastened to strap assemblies by upsetting the ends with sledge hammers. This work is now done better with riveting hammers and at a time-saving estimated by the company to be at least 60 percent. On another operation an air-powered impact wrench is running on nuts, bolts, screws, etc., at a considerably faster rate than that job was done previously—cutting time in one instance from eight to two hours.

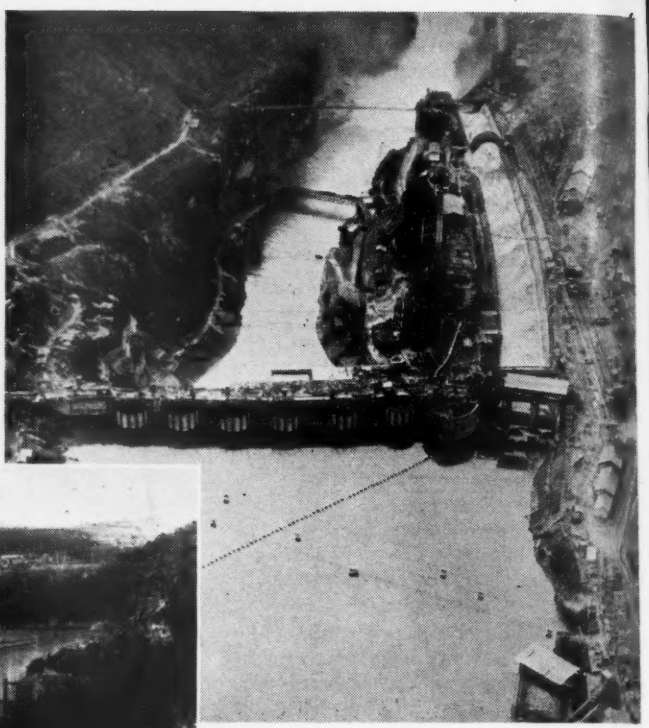
Finished blocks go from the plant to many industries where they serve manifold purposes. In lumbering they are used for snaking logs out of forests, lifting and transporting cut lumber, and moving heavy pieces of equipment. On construction projects they are found on cranes, derricks, power shovels, etc. In oil fields they raise and lower strings of drill rods, casing, etc., and are of aid in hoisting and shifting bulky machinery. In underground mines they are utilized in connection with scraper hoists and transport equipment, materials, and supplies. And in factories they are in great demand for the handling of materials. Cargo ships are perhaps the largest single user. An ordinary-sized freighter carries more than 400 ranging from 3-inch blocks for hoisting signal halyards to multiple-sheave blocks capable of lifting 50 tons.

The tackle block is one of the earliest of man's inventions, yet no substitute for it has been found. Wherever something heavy has to be lifted, it can be counted upon to do the job quickly, easily, and with comparatively little power. This fact was recognized thousands of years ago and is as true today as it was then. Tackle blocks are an important part of our industrial scene and seem destined to remain so for a long time to come. They are built for hard usage, a point that is stressed in the company's advertising slogan: "Madesco Blocks Stand the Gaff."

French Hydroelectric Program

Around 40,000 Men are Working on More Than Forty Projects in an Effort to Meet a Pressing Need

G. Constantini



GENISSIAT DAM

At the right is a general view of Genissiat Dam, the largest hydroelectric power plant in France. Situated on the Rhone River, only 15 miles from the Swiss border, its construction was begun in 1937 but had to be abandoned during the war, when diversion works were destroyed. Activities were resumed when peace was declared, and four generators will be in service at the end of this year, with two more to be put in place. The picture shows excess water flowing through a spillway channel at the right. The downstream face with the powerhouse under construction is seen in the lower view. The dam is 400 feet long at the crest and rises 315 feet above the river bed.

IN THE past few years a tremendous increase in electric-power requirements has been noted the world over and particularly in the European countries which suffered most from the war. This is attributable to the fact that they are faced with the problem of rebuilding their entire economic structure and to the tendency among nations to raise the people's standard of living. Postwar power production in most cases is far too low to help carry out a program of such proportions, and it is therefore necessary where possible to develop hydroelectric resources.

Before World War II, output of electricity in France, though sufficient for her needs, appeared ridiculously low in comparison with that of other countries. In 1937, for instance, Norway produced 3189 kwhr. per capita, Switzerland 635, the United States 1117, and Germany 654, while each Frenchman was supplied with only 433. At that time the total French output did not exceed 22 billion kwhr. annually, and more than half of that amount was obtained from steam plants burning first-grade coal.

Unfortunately, France's coal reserves were and still are inadequate for domestic requirements, and the nation has always had to depend on imports from such countries as England, Germany, and the United States to supplement her supply. This did not matter much before the war because French economy was in a position to carry the burden, but today the situation is different. Imported coal is expensive and has to be paid for in hard currency which France needs badly to buy food and equipment. Furthermore, most of her steam plants, which are operating with machinery that should have been scrapped years ago, burn as much as 2 pounds of coal to produce one kilowatt-hour, and their average efficiency does not exceed 50 percent of that obtained in 1939.

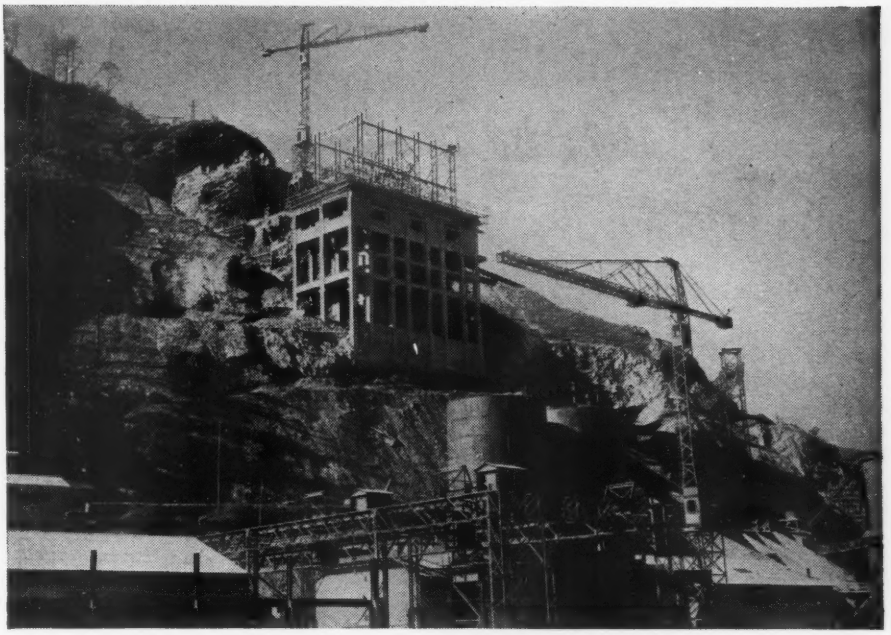
Because of these conditions, the electric-power situation in France after liberation was critical. While the Germans were occupying the country no work of any importance could be undertaken and most construction projects had to be abandoned. Equipment was worn out because it had not been taken care of or repaired for several years. With these run-down facilities the industry faced a tremendously increased demand for power, which is expected to grow from 22 billion kwhr. in 1937 to 39 billion kwhr. in 1951.

It was estimated that the 1946 power consumption would reach 24.9 billion kwhr. and that hydroelectric plants would provide thirteen billion of this total. On account of exceptionally dry weather, French producers could not supply that amount, and electricity had to be stringently rationed. Long and frequent cuts at the beginning of 1946 disorganized industry and slowed down reconstruction. Most factories had to close their gates at least one day a week and, altogether, several million workhours were lost during that period. To produce the largest possible block of power, the steam plants did not stop running for several months, and it was a real achievement to make the strained machinery operate so long and so continuously. In any event, positive action had to be taken to prevent further industrial curtailment because of a lack of electrical energy.

A general building program envisioning an average delivery of 1000 kwhr. per capita by 1951 was proposed, and this scheme is now in progress. By making maximum use of all available power resources, producers of electricity expect within five years to develop about 39.5 billion kwhr. per annum. Of this total, 23.5 billion will be supplied by hydroelectric stations, 11.7 billion by steam plants burning coal waste products and blast-furnace gas, and only 4.3 billion will be generated by imported first-grade coal. In accordance with this plan, existing steam plants will soon be provided with modern, efficient equipment, but of still greater significance is the hydroelectric phase of the project.

Just before the war, in 1938, energy obtained from falling waters was rated at approximately 11.6 billion kwhr., but even then the amount was considered small in relation to the potentiality of the river system. Because of their position and formation, the Alps, the Central Plateau, and the Pyrenees are an inexhaustible source of hydroelectric power. Narrow valleys and sudden drops in elevation in these three areas make them especially well suited for the construction of dams.

Even before the war, when coal was still cheap and easy to get, French engineers were especially interested in waterpower, and their works ranked among the world's best. The dams they reared are mainly located on the Rhone River and its tributaries and on those of the Garonne. In 1939 plants of this kind were already delivering more than half the country's supply of electricity, but a series of new projects was underway, including the famous Genissiat works.



CONCRETE MIXING PLANT

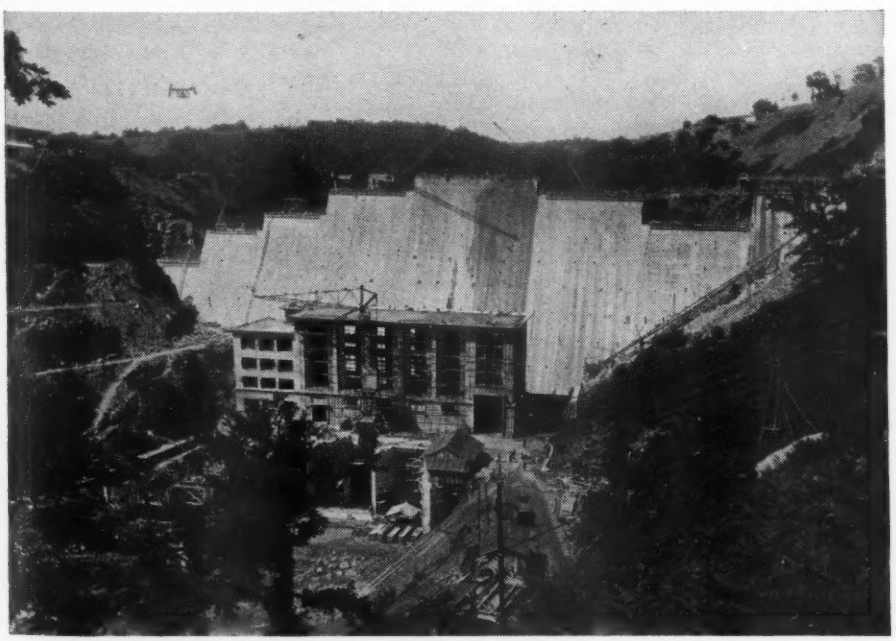
These facilities were set up to supply 815,000 cubic yards of concrete for the Bort Dam on the Dordogne River, the largest tributary of the Garonne. The dam is 1140 feet long at the crest and 360 feet high, and in its powerhouse are two 135,-800-hp. turbogenerators.

Started in 1937 by the Compagnie Nationale du Rhone, the Genissiat Dam is located at a point on the Rhone 30 miles downstream from Geneva and only 15 miles from the Swiss border. There the valley is only 400 feet wide. Preliminary operations consisted in drilling two provisional tunnels—one on each bank and with a cross section of 255 square feet—and in building two cofferdams to isolate the working sites. After many difficulties, caused by the force of the flow, diversion of the stream was completed in 1939. The remaining water was removed by pumping, and tons of silt were cleared from the river bed.

All this preparatory work was nearly finished when an order from the French military authorities brought everything to a standstill and the tunnels had to be closed. The Rhone returned to its natural bed, sweeping away the cofferdams and destroying the results of two years' effort. A few months later, after the armistice between the Vichy Government and the Germans had been signed, the job was resumed, but it took eight months and half a million dollars to restore it to its former condition.

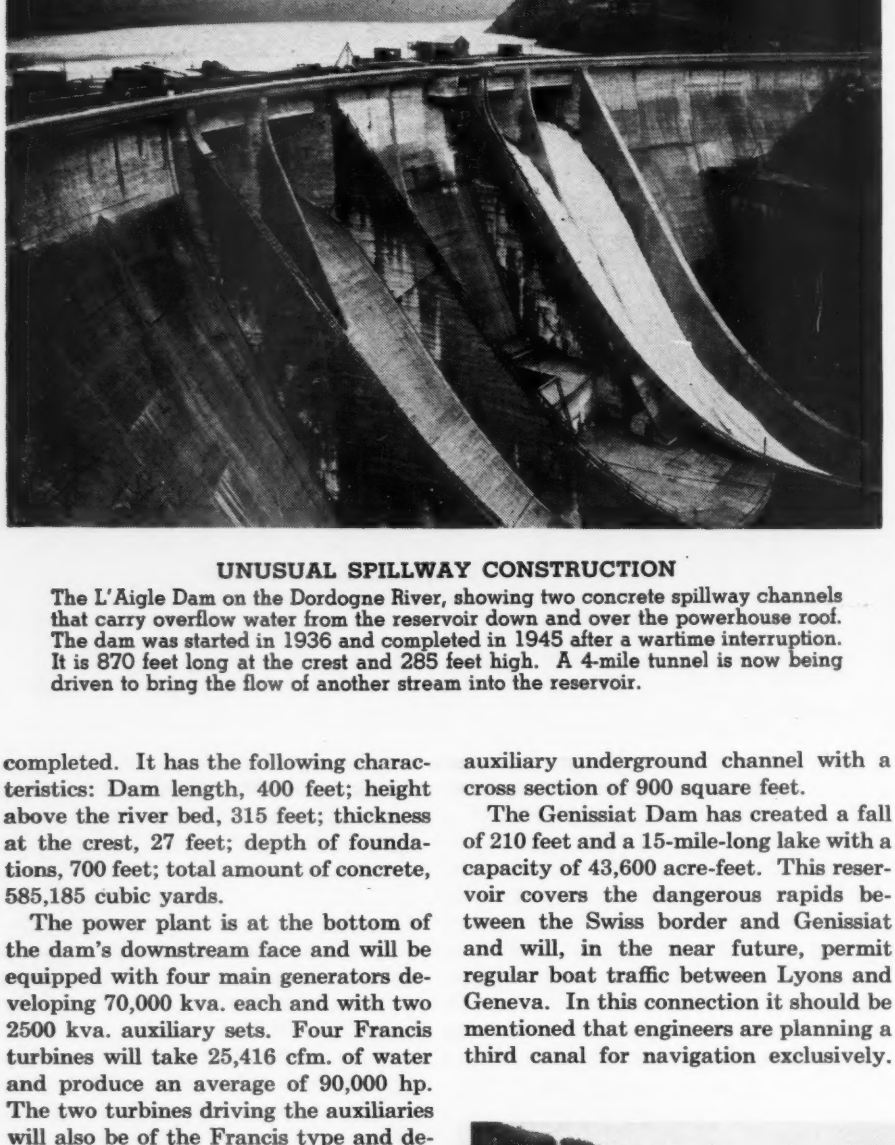
With the war still going on and the Germans occupying France, construction of the Genissiat Dam was delayed until 1945, giving the contractors plenty of time to study and complete their plans. In consequence, when hostilities ceased, everything was in readiness to start anew, and in 1946 as much as 3407 cubic yards of concrete was poured per day with old-fashioned machinery. In the course of that year, 392,593 cubic yards was mixed and placed in the structure, that amount constituting a European record. In the meantime, six penstocks, with a length of 175 feet and an internal diameter of 18 feet, were laid and reinforced by building a heavy steel structure around them.

At the beginning of 1949, less than three years after work really got underway, the main part of the project was



CASTELNAU-LASSOUTS DAM

This structure on the Lot River, a tributary of the Garonne, is nearing completion, as the picture taken in May, 1948, shows. It is 158 feet high, 547 feet long at the crest, and contains 137,000 cubic yards of concrete. Its three generating units will produce an average of 108 million kwhrs. of electricity a year.



UNUSUAL SPILLWAY CONSTRUCTION

The L'Aigle Dam on the Dordogne River, showing two concrete spillway channels that carry overflow water from the reservoir down and over the powerhouse roof. The dam was started in 1936 and completed in 1945 after a wartime interruption. It is 870 feet long at the crest and 285 feet high. A 4-mile tunnel is now being driven to bring the flow of another stream into the reservoir.

completed. It has the following characteristics: Dam length, 400 feet; height above the river bed, 315 feet; thickness at the crest, 27 feet; depth of foundations, 700 feet; total amount of concrete, 585,185 cubic yards.

The power plant is at the bottom of the dam's downstream face and will be equipped with four main generators developing 70,000 kva. each and with two 2500 kva. auxiliary sets. Four Francis turbines will take 25,416 cfm. of water and produce an average of 90,000 hp. The two turbines driving the auxiliaries will also be of the Francis type and develop 2500 hp. Each turbine is protected by a 16-foot-wide butterfly valve that regulates the flow of water passing through it. These valves are strong enough to withstand any pressure to which they might be subjected even in case of an exceptional rise of the Rhone. Forty-pole alternating generators deliver power at 15,000 volts, but this voltage is immediately stepped up to 220,000 by 3-phase units developing 70,000 kva. each. The current generated is transmitted by high-tension cables mainly to Paris and its environs. Two generators are already in service and two others will be before the end of 1949. The fifth set is now under construction and the sixth will be ordered soon.

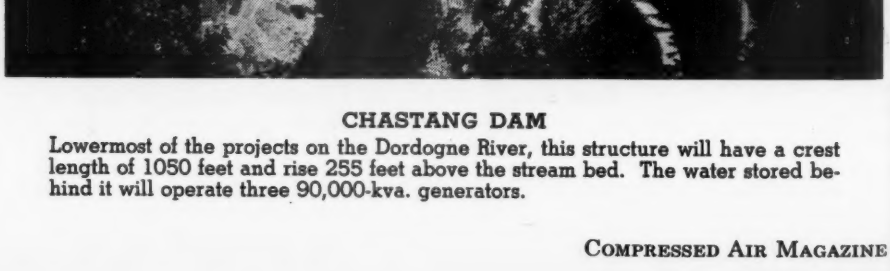
To drain off excess water should the Rhone rise suddenly, two diversion channels have been drilled. The main one, an open cut 1650 feet long, is on the right bank of the river. It begins at a point just upstream of the dam and ends 1200 feet downstream. Six heavy sluices control the flow. On the left bank is an auxiliary underground channel with a cross section of 900 square feet.

The Genissiat Dam has created a fall of 210 feet and a 15-mile-long lake with a capacity of 43,600 acre-feet. This reservoir covers the dangerous rapids between the Swiss border and Genissiat and will, in the near future, permit regular boat traffic between Lyons and Geneva. In this connection it should be mentioned that engineers are planning a third canal for navigation exclusively. It will be equipped with three locks or with a ship's elevator.

When completed within a couple of years, the Genissiat installation will be among the world's largest. At the end of 1949, with only four generator sets operating, the plant will deliver 1550 million kwhr. annually, and this figure is expected to reach 1700 million when all the units are in service. The output will represent more than 10 percent of France's total hydroelectric energy and will go far to lift power restrictions there in the near future.

Particular emphasis is being placed on the Genissiat scheme because it is the most impressive and most efficient of its kind ever undertaken in France. However, more than 40 other waterpower projects are now underway in the Central Plateau, the Pyrenees, and the Alps regions. The Dordogne, the largest tributary of the Garonne River, is undoubtedly the most productive stream in the Central Plateau area. In its upper reaches there will soon be four big dams which, together with three smaller ones in the same section, will provide an average of 2150 million kwhr. per year. One of these is located at Mareges and was in operation before the war. Next is the L'Aigle Dam which was started in 1936 and finished in May, 1945.

The latter structure is semicircular in shape, 285 feet high, and 870 feet long at the crest. Its reservoir has a capacity of 160,000 acre-feet and is expected to deliver 500 million kwhr. annually when the powerhouse, on the dam's downstream face, is fully equipped with four main generating units developing 60,000 kva., plus one 7000-kva. auxiliary set. The Francis turbines use an average of



CHASTANG DAM

Lowermost of the projects on the Dordogne River, this structure will have a crest length of 1050 feet and rise 255 feet above the stream bed. The water stored behind it will operate three 90,000-kva. generators.

ALPINE SETTING

Upstream and downstream views of the Castillon Dam on the Verdon River in the southern Alps. It is 600 feet long at the crest and 300 feet high. In addition to generating power, some of the reservoir water is being diverted for irrigating purposes.

159,000 cfm. of water. Two of the main generator sets are already in service, the third will be installed in 1949, and the last one soon thereafter.

Two interesting elements have been introduced in the construction of the L'Aigle Dam: First, to drain off any excess water in case of floods there are two concrete channels in the power-plant roof itself, a feature that gives the works a very peculiar aspect. Several tests under varying water pressures have been made of the new design, and all have proved it to be satisfactory. Second, to increase the reserve power and the water supply, the Luzege—a small tributary flowing into the Dordogne a few miles downstream from the dam—will be diverted to the reservoir through a 4-mile tunnel that is now being driven.

To complete the harnessing of the Dordogne River, two other dams—the Bort and the Chastang—are now underway. The Bort, which was begun in 1942, will be 360 feet high, 1140 feet long at the crest, and impound 368,000 acre-feet of water. It will call for the use of 815,000 cubic yards of concrete, and its power station and drainage channels will be similar to those of the L'Aigle barrier. There will be two 16-foot penstocks each feeding a turbine of the Francis type developing 135,800 hp. Two 100,000-kva. generators will produce yearly 360 million kwhr. at 15,000 volts, which will be stepped up immediately to 220,000 volts.

The Chastang, the farthest downstream on the Dordogne, was also started in 1942. It will be 255 feet high above tail water and 1050 feet long at the crest. A total of 296,500 cubic yards of concrete will be required for its construction, and its reservoir will have a capacity of 144,500 acre-feet. In the power plant there will be three generating units with an average output of 540 million kwhr. annually. Each will consist of a 90,000-kva. generator and of a 115,000-hp. Francis turbine. Within five or six years the work on the Dordogne will be completed, and by that time the Central Plateau area will provide more than one fourth of the hydroelectric output of France.

The structures in the Pyrenees, though less impressive than those located on the Central Plateau and in the Alps, involve much less cost than the others and promise to be highly efficient. Fifteen works are now underway there, but most of them will develop only 50 to 100 million kwhr. per annum. However, two of the stations deserve special mention: The Aston, on the Ariege River, and the Pragneres at Cap de Long. The first, equipped with two 28,000-hp. turbines of the Pelton type and with two 24,000-kva. generators, will produce 375 million kwhr. yearly. The output of the second, with three 105,800-hp. Pelton turbines each driving an 80,000-kva. generator, is expected to reach 430 million kwhr. annually.

In addition to these new projects, a comprehensive plan which has for its aim the modernization and improvement of all the prewar set-ups in the Pyrenees is being gradually carried out. Its accomplishment within five years is expected to increase the 1939 regional output by as much as 20 percent. Despite all this, the energy from the Central Plateau and Pyrenees streams will be far less than that produced by the power plants in the French Alps.

This article started out with the Genissiat project, which is considered the high light of the entire hydroelectric program. But another exceptionally big installation at Donzere-Mondragon, also on the Rhone River, plus twenty medium-sized dams are now being built in the Alpine region. By the time they are all in operation in 1952, the power output there will have been increased by seven billion kwhr. since the end of the war and will represent more than half of France's total hydroelectric production.

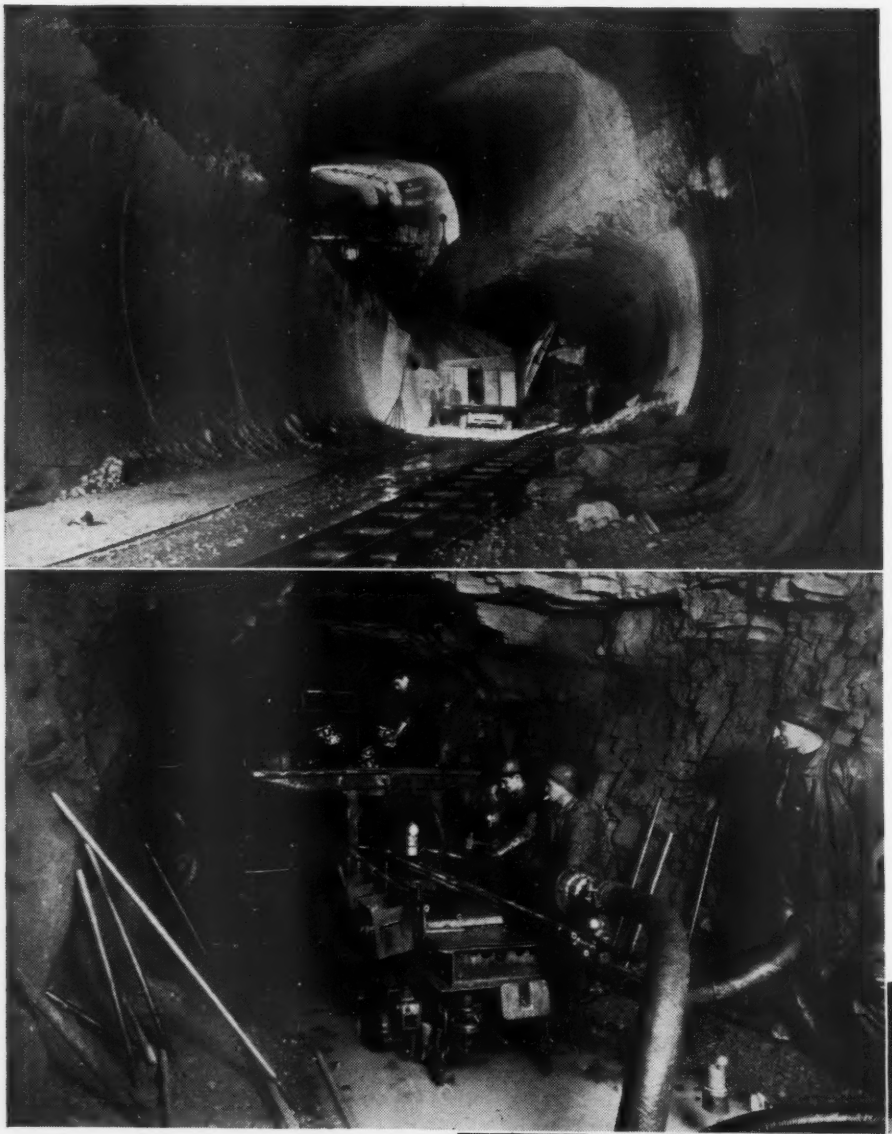
Most of the dams in the Alps are situated near the Swiss border, while the Castillon and a few others are in the southern spurs of the range. Harnessing the Verdon, a tributary of the Rhone River, the Castillon Dam will impound 121,500 acre-feet of water. It will be 300 feet high, 600 feet long at the crest, and only 12 feet wide at the top. Around 141,000 cubic yards of concrete will enter into its construction. Two penstocks, 270 feet long and 10 feet in diameter, will lead the water to four 18,000-hp. Francis turbines each driving a 17,000-kva. generator. This installation will have a twofold effect on the local economy: primarily, it will develop an average of 80 million kwhr. per year and, in the second place, a large quantity of water will be diverted from the storage basin to help irrigate the rather dry surrounding countryside. Some difficulty was experienced in building the dam because of numerous fissures, from 1 to 3 feet wide, encountered on the right bank of the Verdon River. These were inspected and sealed by grouting. Tests conducted after the completion of this work indicated no trace of infiltration even at a pressure of 4700 psi.

All the projects described so far are of the customary type, which consists of a barrier forming a reservoir big enough to supply water continuously to a power plant either at the bottom of a dam or on the bank of a river. Obviously, such plants must be located on large streams. But lesser waterways also are potential sources of electric energy, and in order to develop them French engineers are now engaged in creating many small collecting basins in different streams in the same area and connecting them by open cuts or tunnels. All the water impounded in this manner is delivered to a main reservoir, from which it is conveyed to one or several steeply inclined penstocks by a tunnel lined with reinforced concrete and usually 6 feet in section and not more than 6 miles in length. The longest penstock in France is that located at Luchon, in the Pyrenees, and extends for a distance of 3600 feet.

Systems of this kind call for much preparatory work. First, it is necessary to establish the exact sites of the dams, next to examine with care the geological formation of the entire area, and, finally, to determine how the reservoirs are to be interconnected. This is done with the help of core drills and, in some cases, by boring 50- to 150-foot exploratory tunnels or shafts.

Open cuts are infrequent because mountainous terrain does not lend itself to excavations of this type. Where used, they are usually trapezoidal in section, 6 feet deep, 12 to 16 feet wide, and from 1 to 4 miles long. All drilling is done with Jackhamers or wagon drills, and broken material is removed by hand and sometimes with the aid of pneumatic shovels. Drilling speed varies with the character of the formation; in medium rock it averages around 30 feet a day. Where soft or permeable ground is encountered, the trench walls and bottom are covered with concrete to prevent seepage. In the open cuts, water flows by gravity.

Where tunnels are driven and the distance between dams does not exceed 4 to 5 miles the work proceeds from both portals. These bores range from 6x6 to 14x14 feet in section and are horseshoe shaped. Tunnels more than 5 miles long are usually advanced from several headings opened up by sinking shafts along the proposed tunnel line or by cutting adits into the mountainside. The latter are from 200 to 900 feet long and wide enough so the drilling and other equipment can pass through freely. The number varies with the tunnel length, but two, on an average, are driven for each 9 miles, providing four working faces. Where the adits penetrate soft ground, they are timbered but never lined with concrete because they have to be caved



TUNNELING OPERATIONS

The topmost picture was taken during the driving of an outlet tunnel at Genissiat Dam to serve as an auxiliary spillway in the event the open cut shown at the beginning of the article cannot handle the flow. In the center is a drill carriage equipped with five DA-35 drifters in use in a tunnel at Sechilienne in the Alps area. To expedite work on long tunnels, headings are opened up in addition to those at the portals by driving adits to intersect the line at intermediate points. As these are not permanent, they are supported in loose ground with timbers, as shown at the right. The overhead pipe carries ventilating air, while the small pipe on the floor is the compressed-air line.

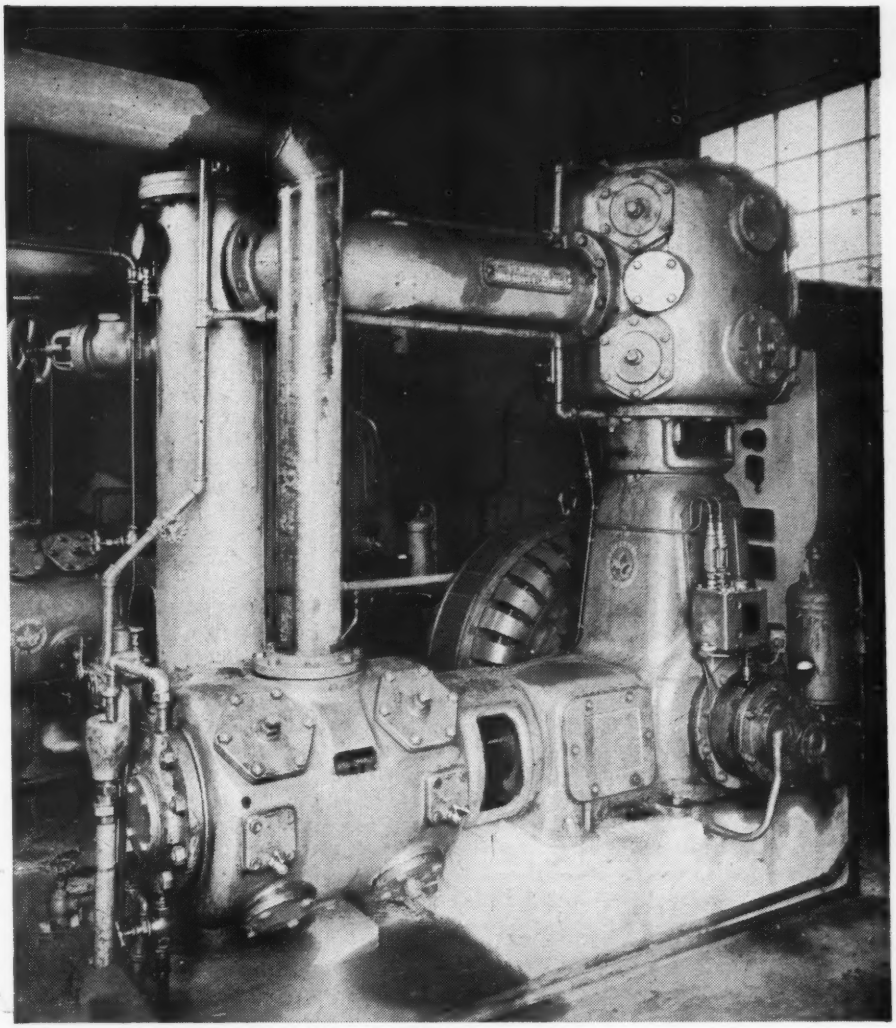
in by blasting once tunneling is completed. The shafts range from 10 to 16 feet in diameter and are not more than 200 feet deep. They are excavated by means of wagon-mounted drills and Jackhamers.

Tunneling is done with Jackhamers mounted on Jacklegs and with drifters on drill carriages, the latter being preferred because the jumbo method is more convenient for work of this kind. There are different types of drill carriages in use and they are equipped with from two to six drifters, depending upon the size of the heading. In some of the biggest bores the contractors operate twelve drifters mounted on two jumbos at the same face.

The working headings are kept as dry as possible by the use of sump pumps. Drilling speed varies from 6 to 16 feet per shift, according to the nature of the formation, and mucking is done with the help of pneumatic shovels. In ground too soft to stand unsupported, the tunnels are timbered and then covered with concrete. To save time, concreting is done while drilling is going on. In most cases the tunnels are being driven to permit gravity flow, but in some short stretches the water will have to be pumped. The pumping stations provided for the purpose will be powered by the hydroelectric plants in the areas.

When all the projects included in the present program are completed, the Alps will be the biggest waterpower reservoir in Europe, despite the fact that most of the region's hydroelectric resources will still be untapped. Technicians affirm that if nothing happens to oppose their plans, the area's output within 30 years will come close to meeting France's total power needs. The nation will then be able to reduce her coal imports to a minimum and even export some of the energy generated by her hydroelectric installations. Much has already been achieved towards this end, for in less than four years after the liberation of France in excess of 100 projects have been started or resumed. Many of them are already contributing to the country's reconstruction effort, and in 1952, at the end of the emergency program, waterpower plants will be producing 25 billion kwhr., as against eleven billion in 1938.

This huge task is being realized despite a lack of means and tremendous obstacles. Credits had to be found and a strong organization created. Fortunately, this did not take long, the French Government being well aware of the importance of electricity to the nation's economy. All the big companies controlling or concerned with generating power, with the exception of the Compagnie Nationale du Rhone, were nationalized and merged into one administrative body—Electricite de France. Yet this organization, with well-nigh unlimited credit at its disposal, has to call on private enterprise to help finance the undertaking.



SOURCE OF AIR SUPPLY

One of six Canadian Ingersoll-Rand air compressors in use at the Passy Dam site in the Alps area. It is driven by a 127-hp. synchronous motor.

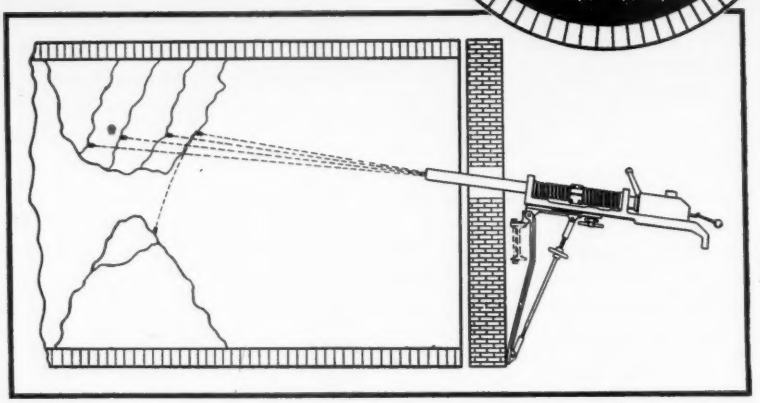
The main functions of the Electricite de France are manifold and consist in general program planning, coördinating the results obtained, dealing with the contractors in the name of the government, and securing for them the necessary equipment. This latter phase is of the utmost importance because the big French contracting firms lost most of their machinery during the war. Some of it was carried off by the Germans, much of it was destroyed, and what remained in 1945 was largely worn out or obsolete.

To expedite matters, the organization immediately mapped out a purchasing program. A small percentage of the equipment was obtained from French industry and from American War Surplus Camps, but most of it had to be imported from the United States. With the dollar credits allowed by the French Congress, contracts were made with big American firms and the latest in rock drills, mountings, compressors, pumps, loaders, trucks, shovels, etc., was purchased. Now most of the works are partly equipped with modern machinery, a situation that will improve progressively through the aid of the European Recovery Program until operations at all the dam sites can proceed with maximum efficiency.

Labor also imposed a problem at the outset because French workers were not keen on going to isolated camps at high altitudes. In February of 1947 only 20,000 men were employed on all the jobs, and foreign labor had to be imported, mainly from Italy. At the end of that year, as a result of numerous incentives—decent living conditions, good food and high pay, more than 40,000 were living in the small communities created by Electricite de France. Some of the quarters are of permanent construction and attractively furnished and are intended to serve as rest and vacation camps for children when work on the far-flung hydroelectric program is completed. Then France will rank among the world's leading nations in per capita output of electric power.

IN CEMENT-MILL SERVICE

Originally developed for removing clinker rings from rotary kilns, the gun is still used mostly for that purpose. Many mills mount one on a horizontal beam in front of the kiln opening, as pictured at the left. The drawings show the point at which the shots are aimed. A few fired into the top of the deposit (circular sketch) usually loosen a key segment, causing the remainder of the ring to fall when the kiln is slowly rotated.



INDUSTRIAL GUN HAS MANY USES

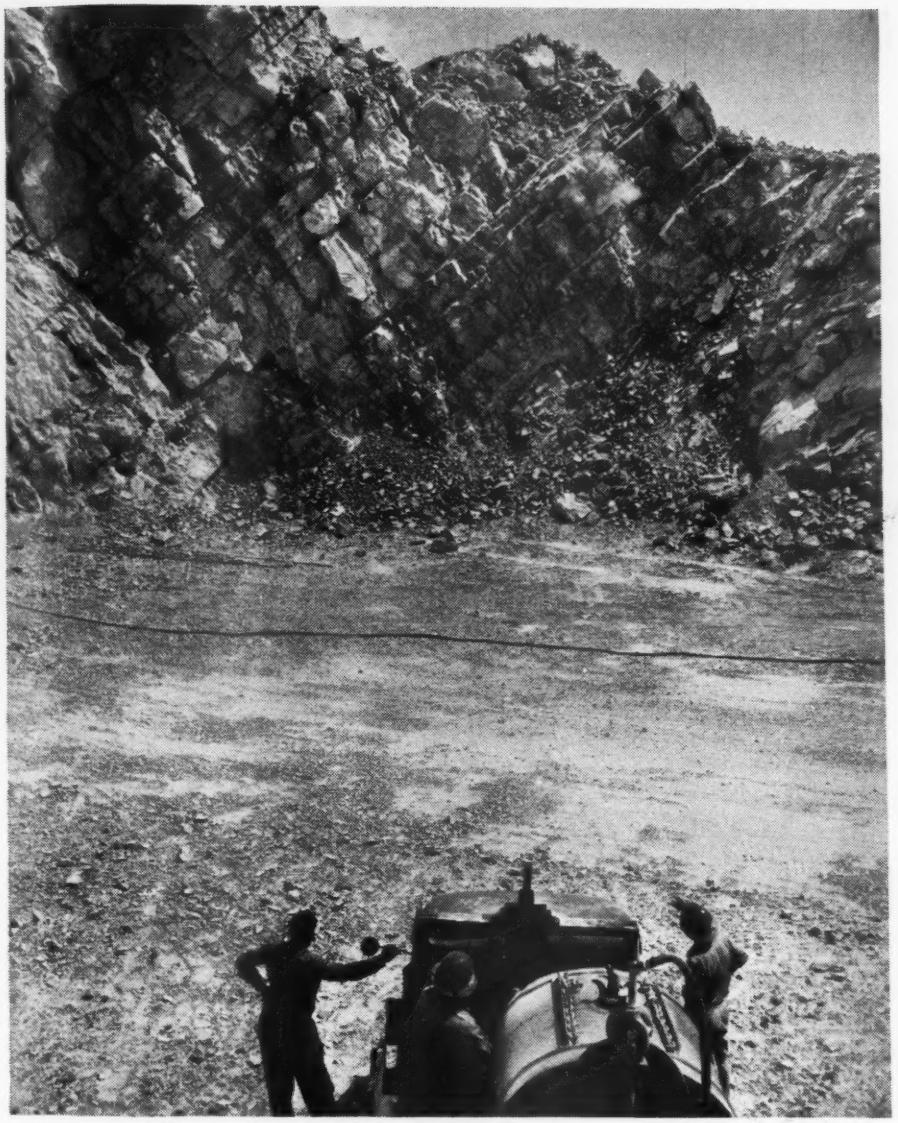
AN INDUSTRIAL gun that was developed some years ago to solve a special problem in the Portland-cement industry is now being applied to other fields of service. Quarries and open-pit mines use it to shoot down loose, overhanging rocks high up on working faces and to dislodge key rocks in muck piles to start the material moving and thus facilitate loading it with power shovels. Occasionally, the weapon has been employed in mines and tunnels for removing icicles from overhead.

The gun, which is made by Remington Arms Company, Inc., at its Ilion, N. Y., factory, weighs 92 pounds, has a 36-inch barrel, and shoots a 3-ounce lead projectile of approximately 8-gauge that resembles an oversize shotgun shell. The firing piece develops a muzzle velocity of 1600 feet per second and a muzzle energy of 7475 foot-pounds. It is discharged by means of a lanyard and equipped with an automatic shell ejector.

In some cement mills trouble is experienced with clinker rings that form inside rotary kilns in which the raw materials are calcined. The slaglike deposit builds up to a thickness that reduces the internal diameter of a kiln and proportionately reduces the quantity of material that can be put through in a given time. These rings are of two types, "cold" and "hot." The former are generally found within 10 or 15 feet of the feed end where temperatures are rela-

UNDERGROUND

A truck-mounted gun being fired in an underground mine to scale down loose wall material.



QUARRY MARKSMEN

Parked at a safe distance, workmen in a limestone quarry of the United States Lime Products Corporation at Apex, Nev., bring down blocks of stone that would otherwise have to be removed by dangerous and time-consuming methods. The truck mounting facilitates moving the gun around as desired.

tively low. The others are deposited in the hotter zone, usually from 25 to 40 feet from the end.

To break up these accumulations, it was formerly necessary to shut down the kiln, wait until it cooled, and then send in a gang with sledge hammers or similar tools. With that work done, the kiln had to be brought up to the prescribed temperature before operations could be resumed. Obviously, this procedure consumed a lot of time and seriously lowered mill production.

The Remington Cement Gun, forerunner of the present industrial model, was developed to remedy this situation. In many mills where ring formations have to be removed periodically, the improved weapon is mounted permanently on a horizontal I-beam at the opening of the kiln and is supported on a bracket or bolster designed for that purpose. For taking aim, the piece can be maneuvered horizontally by a hand crank and vertically by a hand wheel.

As shown in an accompanying sketch, the first few shots are directed at the upper part of the clinker ring, thus breaking out a keyway. The kiln is then rotated slowly, whereupon the remaining segments usually fall. If they do not, a few more shots accomplish the desired result. As the projectiles are fired at a low angle to the walls of the kiln, the brick lining is not damaged even when the soft-lead slug passes through the incrustation and strikes it.

With the industrial gun, one worker can break up clinker that formerly required the efforts of several men. Of course, it is no longer necessary to allow the kiln to cool when dealing with "cold" rings, because they are shot down while it is in motion. But in the case of "hot" rings, rotation is stopped just long enough to go through the procedure previously outlined. When the weapon is installed permanently, the manufacturer recommends cleaning its working parts, or "action," with compressed air at regular intervals. It is also advisable to clean the barrel thoroughly before and after firing so that it will not become obstructed.

For quarry and mine service, the gun is ordinarily mounted on a truck so that it can be readily moved into position for use wherever it may be needed. Following blasts, large chunks of material are often loose but do not come down and obviously constitute hazards. It is an expensive, time-consuming, and dangerous job to bar them down by conventional methods because they generally entail the erection of ladders or scaffolding to enable workmen to reach them. But with one of these industrial guns they can be brought down in a few minutes with safety. Experience has shown that the soft lead slugs do not rebound or ricochet.

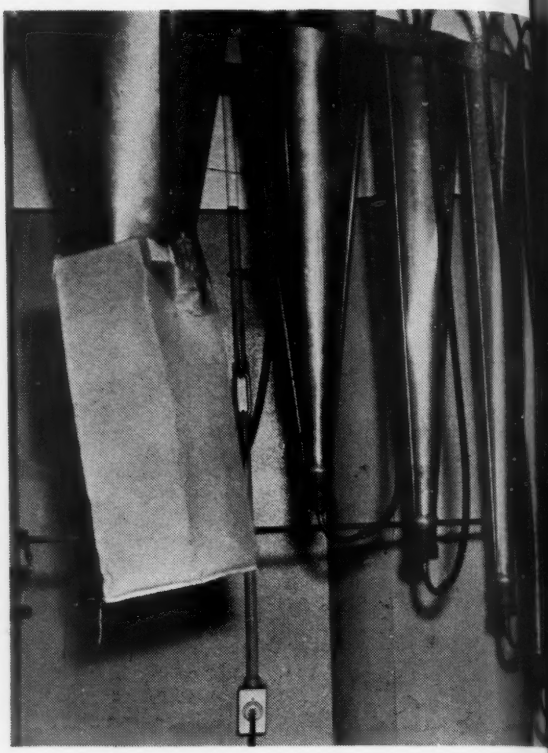
When a pile of blasted muck is being handled by a power shovel, it sometimes "hangs up," forming a high, almost vertical wall that is kept from toppling by one or more key rocks. By working into the base and undercutting the pile, the shovel can cause it to tumble, but this takes considerable time and exposes it, as well as waiting trucks, to damage from falling rocks. In such cases the weapon is brought into play, precipitating a slide with one or more shots after the shovel and other pieces of equipment have been drawn back to a safe distance.

Remington Arms reports that its gun is in use in all sections of the United States in cement mills and other plants where zinc, lime, and phosphate compounds are calcined, while its application in quarries and mines is widening. Twenty units are in service in foreign countries. The ammunition is made in the company's Bridgeport, Conn., factory, and its consumption now exceeds 1,200,000 shells annually.

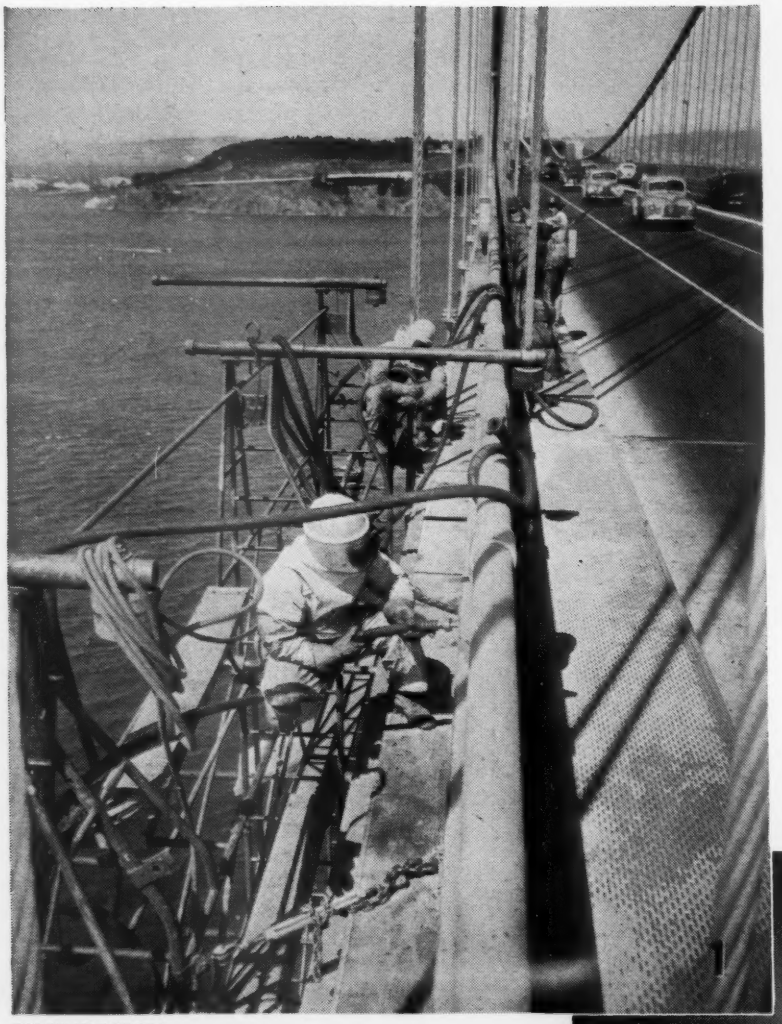
Walkie-Talkie Aids Surveyor

THE walkie-talkie telephone that gave effective service during the war is finding uses in peacetime engineering work. Surveying crews of the Adams Electrical Cooperative say it shortened recent field operations by from 30 to 50 percent. By means of portable, 7-pound units hung from their shoulders, instrumentmen and rodmen kept in constant communication, even when out of sight of one another, all that was necessary was that the top of the rod be visible to the instrumentman. Conversations can be carried on at distances up to 2 or 3 miles. Trucks of the Cooperative have been equipped with the phones to keep in touch with line patrolmen during storms.

U. S. STEEL PHOTO



COMPRESSED AIR AT WORK



WIDEWORLD PHOTO

1 Workmen painting San Francisco's Golden Gate Bridge use air-operated chippers and sandblasting equipment for cleaning surfaces. They wear air-fed helmets to protect them from flying particles. The first repainting of the structure has been in progress since 1936 and is still only 85 percent completed. Safety is stressed, and the one serious accident to date was caused by a car which struck a worker on the roadway.

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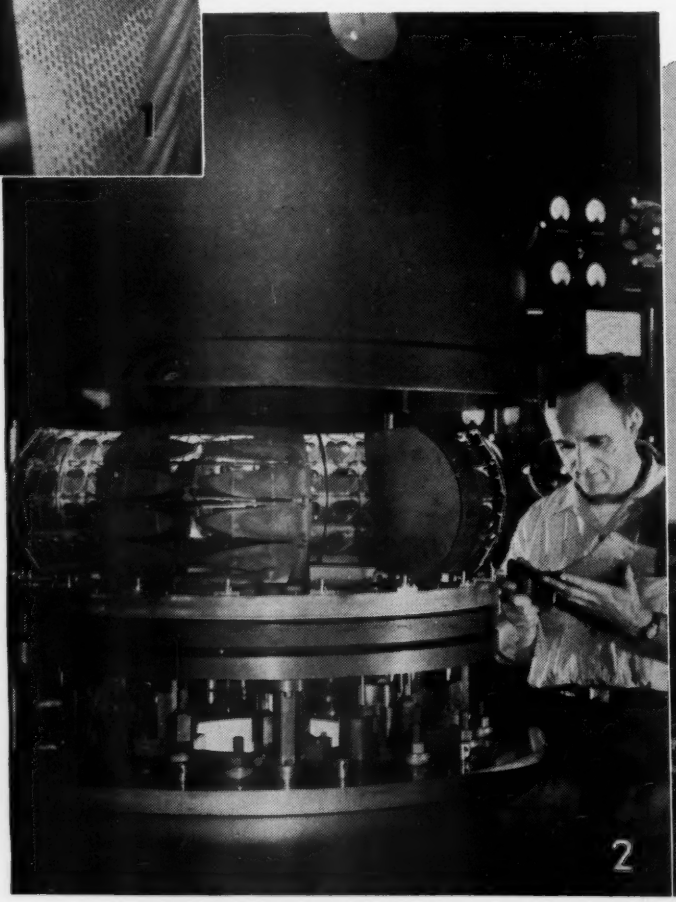


2 In making its "Gradient-Density Ray-Bar" sunglasses, which are much used by aviators, Bausch & Lomb Optical Company coats the upper half of each lens with a semitranslucent film of Inconel metal. The thickness of the deposit is gradually reduced from the top down to the optical center, and this serves to reflect some of the light coming from above without interfering with vision. The material is applied in a huge vacuum bell made by Distillation Products, Inc. The lenses travel around a circular track behind a masking shield that graduates the film, as desired. The picture shows the bell open for loading with lenses.

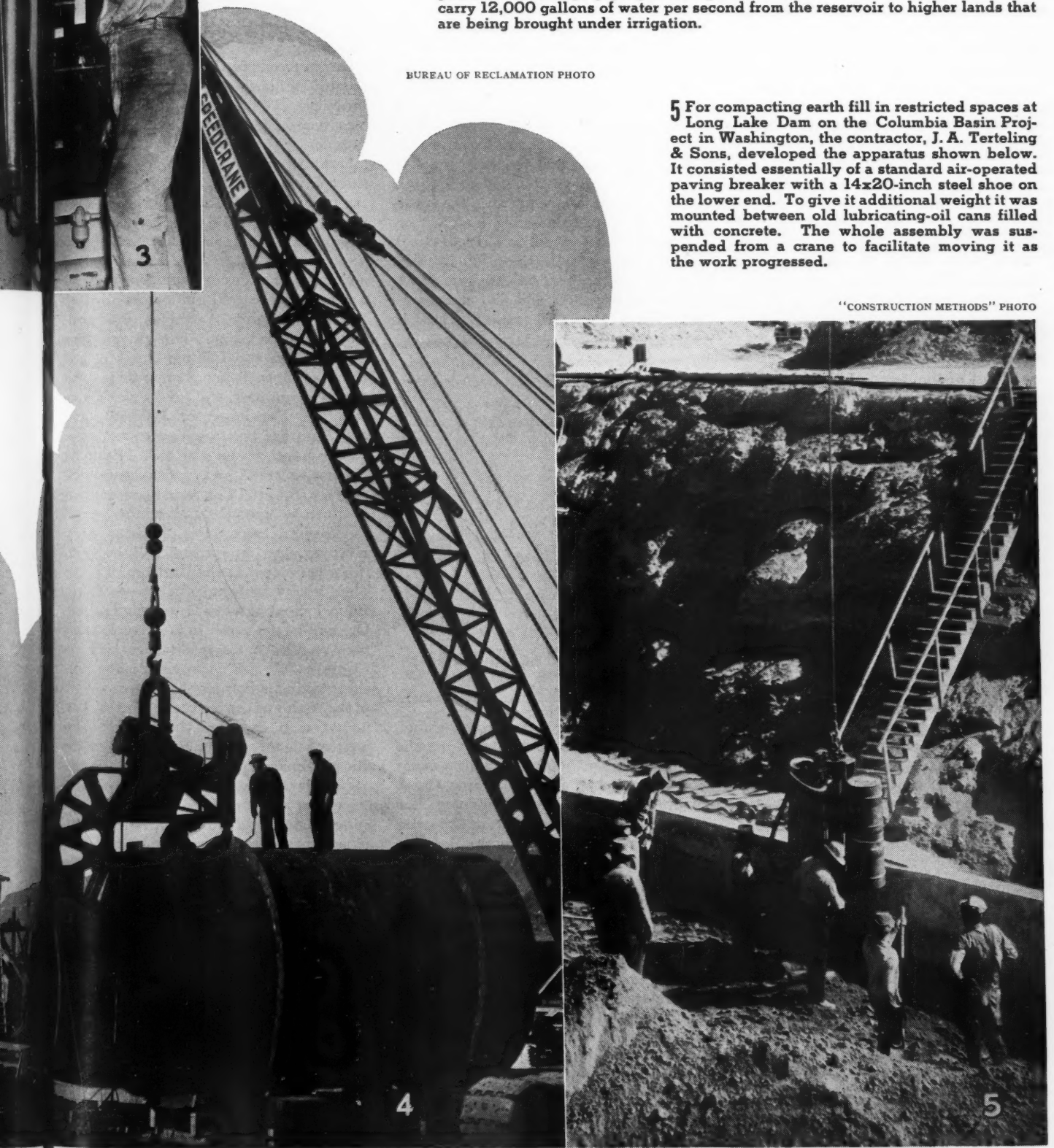
3 One phase of Oliver Mining Company's research activities involves ascertaining at what grain size iron oxide in taconite ore is liberated from the accompanying silica. Because the ore is ground too fine to be separated into various sizes by means of conventional screens, the apparatus pictured at the left was designed to do the work with air. The pulverized taconite is blown into the long thin tube at the right and flows successively through the other tubes from the bottom up and out. Each has a larger top diameter than the preceding one, thus gradually reducing the air velocity so that progressively finer material is deposited in each tube. The finest passes into the bag at the end of the circulating system.

4 Because of its tremendous power, workmen at the Grand Coulee Dam pumping plant call the air-operated clamp shown below, center, "The Bull." It holds the flanges on 12-foot-diameter pipe lengths while they are being welded in place. The section in the foreground weighs 17 tons. Approximately ten million pounds of the huge piping is being assembled into twelve conduits that will carry 12,000 gallons of water per second from the reservoir to higher lands that are being brought under irrigation.

BUREAU OF RECLAMATION PHOTO

5 For compacting earth fill in restricted spaces at Long Lake Dam on the Columbia Basin Project in Washington, the contractor, J. A. Terteling & Sons, developed the apparatus shown below. It consisted essentially of a standard air-operated paving breaker with a 14x20-inch steel shoe on the lower end. To give it additional weight it was mounted between old lubricating-oil cans filled with concrete. The whole assembly was suspended from a crane to facilitate moving it as the work progressed.

"CONSTRUCTION METHODS" PHOTO



Moving Day at Cripple Creek

ONCE so opulent that it might have incited the envy of King Midas, Cripple Creek, Colo., has temporarily suspended gold production. For at least a year mining will halt, except perhaps for some development work. The reason therefor is that the only accessible ore treatment plant, the Golden Cycle Mill, is being moved from Colorado Springs to Cripple Creek. Presaging this shift was the announcement (COMPRESSED AIR MAGAZINE, July, 1948,) that the Midland Central Railroad had applied to the Interstate Commerce Commission for permission to cease service on its 56-mile line from Cripple Creek to Colorado Springs. The remainder of the story is in the annual report to stockholders of the Golden Cycle Corporation.

Besides owning the Midland Central, that concern virtually controls Cripple Creek mining activities, having absorbed, one by one, the various worthwhile properties as they succumbed to insurmountable economic obstacles. Before gold mining hit the skids, the Golden Cycle Corporation, built up by the Carlton Brothers, was in a position where it couldn't lose. Possessing the only railroad out of the camp and the only ore-processing mill within shipping range, it made something on every ton of ore hoisted. In addition to its gold-mining and milling and transportation interests, it operated coal mines and sold ice, fuel, crushed stone, and sundry other products in and around Colorado Springs.

The 1929 crash, which dealt a body punch to business in general, paradoxically gave Cripple Creek a new lease on life. Gold mining has always thrived on depressions, and an added fillip was the 1933 increase in the price of the yellow metal from $20.67 to $35 an ounce. Golden Cycle entered upon a lush period of prosperity in which annual dividends reached $6 a share on its $10 par stock. As a vote of confidence in the future, the company set aside a million dollars in 1938 to drive the 5-mile Carlton Tunnel.

Bored at record-breaking speed to cut the mineralized area below the existing workings, the tunnel put an end to expensive pumping in some of the mines and was hailed as the elixir that would add 25 years to the camp's life. However, before its benefits could be brought to bear, gathering clouds of World War II stiffened prices of everything the mines used and lured most of the younger miners to higher-paying jobs in munitions plants. Even so, with so many aces in its deck, Golden Cycle was able to keep going. In 1942, the War Production Board terminated gold mining on the score that it was a nonessential industry, but Golden Cycle converted its mill to the treatment of base metals and kept it in operation.

When peace returned, things got worse instead of better. Prices of materials continued to rise, experienced miners were scarce, and floaters wouldn't stay on the job. To keep its railroad and mill functioning, Golden Cycle shipped low-grade ore from old dumps. This dilution of newly mined ore reduced the average gold content per ton to $6 during recent years. Since ore freight rates on the Midland Central had always been scaled according to gold content, transportation revenues declined proportionately. From 1943 through 1947 the line lost $276,256, an average of $55,251 per year. "These factors," the Golden Cycle report states, "made it impossible to continue to operate the railroad, except at a heavy loss, and the only relief in sight was to move the mill to Cripple Creek to eliminate as much of the transportation costs as possible."

Removal of the mill to Cripple Creek will be a reversion to the original trend. During the camp's first 30 years somewhere between 50 and 60 mills were established there. The treatment then in vogue called for large quantities of fuel, all of which had to be shipped from the plains, a climb of 5000 feet. This was not economical, and all the Cripple Creek plants were eventually closed down. The Golden Cycle Mill was built in Colorado Springs in 1905 because it was less expensive to transport ore downhill than to haul coal and other supplies uphill. Gradually the mill absorbed the business from all the Cripple Creek mines and also treated ore from other Colorado districts. The Colorado Springs plant became the largest custom gold-ore treatment plant in existence. With contributory revenue from the railroad, its continually growing group of mines, and its extraneous interests around Colorado Springs, the Golden Cycle Corporation prospered.

"That's a lovely basement hole, but it's on the wrong lot."

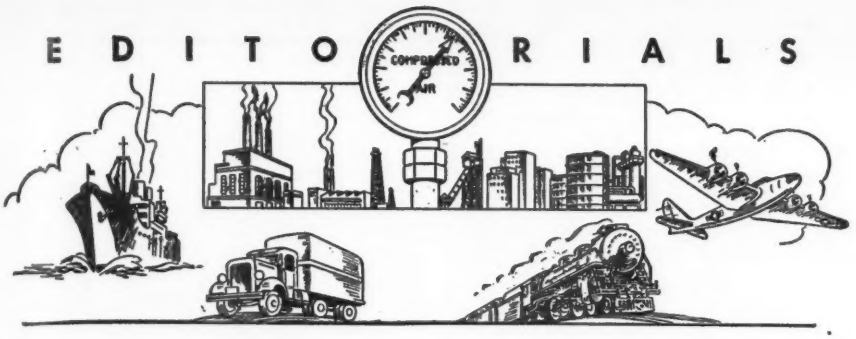
During all this period of more than 50 years, the average recoverable gold content of the ores treated was around $10 per ton. In other words, 2000 pounds of rock was being transported more than 50 miles to extract from it about one-third of an ounce of gold. This expensive mass movement can now be terminated by adopting a milling method that requires less fuel than the old one. It reflects metallurgical advances during the past 25 years.

Prior to deciding upon the new flow sheet, Max Bowen, vice-president who has been in charge of milling operations for many years, visited various beneficiation plants in this country and Canada to familiarize himself with the latest practices. The Golden Cycle laboratory also conducted extensive tests, and samples of the ore were sent to outside laboratories for checking. As a result of these investigations, it is believed that the method decided upon is the most efficient one that could have been selected. Briefly, it consists in treating the finely ground ore in flotation cells and roasting and cyaniding the concentrates. The end product will be gold bullion, as now.

The Midland Terminal Railroad, which was the last survivor among three lines that served Cripple Creek at one time, is now being dismantled. All tracks, structures, and rolling stock were sold last December for $206,391, and that sum has been applied towards the construction of the new mill. Building has been started, and materials and machinery from the Colorado Springs plant that can be embodied in it will be hauled to Cripple Creek. For the most part, however, the equipment will be new.

To be known as the Carlton Mill, the plant is now rising at a site convenient to the principal potential producing mines. Ore will be delivered to it in trucks, and the average haulage distance will be 3½ miles. It will occupy a sloping hillside, taking advantage of gravity flow in the course of the recovery process. The management expresses the view that the high efficiency of the mill and the reduced transportation costs will make it profitable to treat millions of tons of low-grade ore now on the dumps or in the mines that could not stand the added expense of shipment to Colorado Springs.

Coincident with this change in mill location, the Golden Cycle is continuing to drive laterals from the original terminus of the Carlton Tunnel at the Portland No. 2 Shaft to the Cresson and the Vindicator-Cycle properties. The first-named gallery was advanced 1437 feet and the second one 1297 feet during 1948. It is stated that the bore has already more than paid for itself, for production in the Cripple Creek District during the past eight years would have been virtually nil if it had been necessary to bear the cost of pumping water from the workings.



OUR RESTLESS PLANET

THE recent series of minor earthquakes calls attention to the fact that the planet on which we live is still undergoing internal convulsions and is far from "finished" in a sculptural sense. Actually, crustal disturbances recorded by seismographs aggregate, roughly, 9000 a year—about one every hour. Many others are too small or too remote from instruments to be noted, and scientists estimate that the earth annually experiences as many as 60,000 "shakes," big and little.

Earthquakes are surface manifestations of the adjustment of internal strains. Usually, they take the form of crustal movements along fault planes. Cracks appear in the earth's skin, and there is a displacement either up or down of the block of ground on one side or the other. These adjustments have been going on for eons and have left their record in millions of faults that crisscross the surface. Oftentimes they complicate mining operations, and many a paying vein has suddenly been lost when it apparently ran up against a blank wall. It is then up to the geologist to attempt to locate the extension by figuring out which way the ground sheared and how far. Ordinarily, the displacement is no more than a few inches or a few feet, but great movements are by no means rare. Sometimes they leave scars on the surface that can be readily seen from an airplane.

Even a minor movement will cause distinct earth tremors the intensity of which will diminish greatly as they travel away from their plane of origin. When a city happens to be located on the line of displacement, major destruction and casualties will result. The quake that destroyed much of San Francisco in 1906 extended for several hundred miles but had little effect on human beings outside the city. Some of the greatest tremblings ever recorded on seismographs have done no damage and taken no lives because they occurred either at the bottom of the ocean or in some uninhabited land area.

In general, the seismic upheavals occur where there are abrupt changes in surface elevation. The bed of the Atlantic Ocean slopes gently from Europe to North America, and earthquakes are rare on its shores. On the other hand, the Pacific attains a depth of more than 2 miles within a distance of 60 or 80 miles from the coast of California, and mountains rise to a height of half a mile only 150 miles inland. Such great differences in altitude apparently foster disturbances. They probably are attributable to the fact that the sea floor is still subsiding and the mountains are still being uplifted.

In any event, the juxtaposition of elevated land masses and deep ocean areas seems to induce crustal movements. Records long kept by the German Government at Jena prior to the last war revealed that Chile and the deep ocean bed off its coast are the earth's most restless regions. Japan comes next. Actually, for every 1000 quakes felt in Chile, Japan experienced 432 and California only 81.

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WELLAND CANAL ANNIVERSARY

THIS year marks the 120th anniversary of the first Welland Canal, forerunner of the present waterway that permits ships to by-pass the rapids and falls of the Niagara River between Lake Erie and Lake Ontario. The canal now in service is the fourth one constructed across the Niagara Peninsula. It was seventeen years in the making and will have been open for traffic seventeen years on August 6.

Time has obscured the name of the person who first advanced the idea of the Welland Canal. Suggestions that one be built were offered during the years immediately following the War of 1812 when both the United States and Canada became canal-minded. Col. Robert Nichol attempted to obtain public funds for the project by introducing a bill in the Upper Canadian Parliament in 1816, but the measure was defeated. Thereupon William H. Merritt organized the Welland Canal Company, and residents of the Niagara area bought stock in it. Near the end of 1824, when $150,000 had been raised, the first earth was turned at Allanburg, Ont., by George Keefer, then president of the concern.

The initial waterway contained 40 wooden locks each 22 feet wide and 110 feet long, with a water depth of 8 feet that enabled the small craft of that era to ply between the two lakes. The Erie Canal had been in service since 1825, and in the same year the Canadians opened a watercourse around the Lachine Rapids in the St. Lawrence River near Montreal. Shortly after the Welland Canal was completed the Canadians also constructed the $4,000,000 Rideau Canal between Kingston and Ottawa to provide a military route in the event of another war with the United States. Fortunately, it has never been called upon to serve that purpose. Instead, it created an extensive chain of lakes that affords excellent fishing for thousands of Americans who find the area a restful vacation spot each year.

When shipping outgrew the first Welland Canal the government of Upper Canada built a larger one, finishing the final section in 1850. Each of its locks, formed of cut stone, was 150 feet long, 26½ feet wide, and carried 9 feet of water. By 1871 it was inadequate, and a Canadian canal commission recommended a third waterway, which was constructed with locks 270 feet long, 45 feet wide, and 14 feet deep. It was ready for service in 1887. The 26 dimension-stone locks are still considered examples of fine masonry work.

By 1928 ships 630 feet long, 70 feet wide, and drawing 20 feet of water were plying the Great Lakes, most of them carrying wheat. To accommodate them and the larger ones that were to come, a fourth canal had been started thirteen years before. It deviates from the course of the earlier ones, running almost due north and south for 25 miles across the peninsula. It elevates and lowers vessels 327 feet in their passage between the lakes. Seven of the eight locks by means of which this is accomplished are each 859 feet long, 80 feet wide, and have 30 feet of water at their sills. The eighth lock, which is claimed to be the largest on an inland waterway, has a length of 1380 feet.

More than 62,000,000 cubic yards of rock and earth was excavated from this huge ditch, which is 310 feet wide at the water line and 200 feet at the bottom. The numerous highway and railroad bridges that cross it can be raised to permit ships to pass. The canal carries heavy traffic, except during four months of each year when it is closed by ice. In 1947 it was used by 5915 vessels that transported 11,828,000 tons of freight. It has become an important commercial artery for both the United States and Canada and will play an even greater part in our economy if the St. Lawrence Seaway Project is consummated and especially if the supply of iron ore from the Lake Superior District gives out and we turn to the Labrador deposits. That, it now appears, is what we will probably do.

Industrial Notes

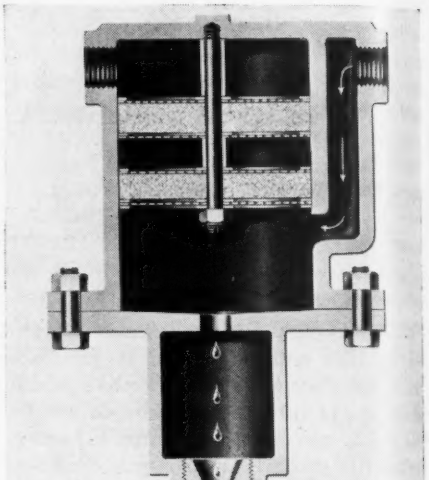
The wheel-mounted barrel stand with rockers shown in the accompanying illustration is a new product made by the Modern Equipment Company for warehouse or industrial use. It is called the Wizard because it serves as a rack for

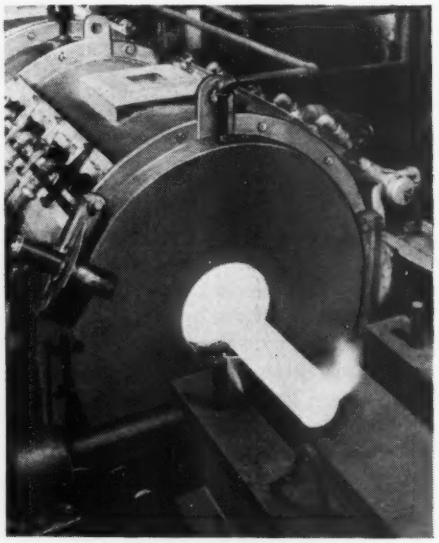
drawing off liquids and permits one man, it is claimed, to pick up a drum in either upright or horizontal position, to move it, and to unload it. It has adjustable handles that are fully retracted in the picture to make room for the can; toes to slip under and hold a barrel when picking it up; a sliding rod with a hook that fits over the rim at the opposite or bung end; and rollers at the top to turn a drum should it have a leaky faucet.

Stainless steel with a carbon-steel backing is being offered by Alan Wood Steel Company under the name of Permaclad at about half the cost of solid stainless. The corrosion-resistant face represents 20 percent of the total thickness of sheets to 13 gauge and 10 percent from that size on through the heavier gauges. The bond is said to be permanent. Standard product is made of Type 304 stainless with an AISI-1008 backing, but both can be varied to give material characteristics to meet specified requirements and are said to retain their individual properties. It can be soldered, arc or spot welded, drawn or stamped, and cold formed.

What is said to be the first all-electric explosionproof heater that complies with Underwriters' Laboratories requirements for Class 1, Group D hazardous locations has been announced by Electromode Corporation. The unit has a cast-aluminum, natural-convection safety grid and a heating element of nickel-chromium resistor wire insulated and sheathed in seamless-metal tubing embedded in a 1-piece, finned, aluminum casting. The heater is thermostatically controlled through a contactor and built for wall mounting. It is primarily designed for use in atmospheres containing gasoline, petroleum, naphtha, acetone, benzol, lacquer, solvent vapors, and natural gas. Three models are available in ratings of 2000, 4000, and 6000 watts.

For use in conjunction with operations such as fine painting, mirror silvering, blowing dust from highly polished or corrosible surfaces, etc., James A. Murphy & Company has developed a separator that is designed to remove the last trace of water, oil, and dirt from compressed air at the point of application. The air enters the unit at the top right and flows into a chamber where most of the condensed moisture is removed through expansion and surface contact. From there the air slowly rises through two cotton-felt absorbent pads tightly packed between perforated brass baffles supported in the filter cartridge by grids and spacers. These pads are said to trap any remaining liquid and grit, delivering dry, clean air for immediate use. The moisture descends into a collector, where it cannot be reabsorbed by the incoming air and from which it may be drained either by hand or by "cracking" the drain plug to allow its escape without air leakage. The cartridge may be removed for cleaning and reuse. The Paragon C, as the separator is designated, is offered in two sizes: No. 1 takes inlet and outlet pipes of ⅛ to ⅜ inch and supplies one ⅛-inch pipe nozzle; No. 2 accommodates ⅛ to ¾-inch inlet and outlet pipes and feeds four ⅛-inch or two ¼-inch nozzles through a manifold.





DOUGHNUT-SHAPED FURNACES

To heat them to the specified temperature for rolling, pierced seamless-steel tubes are passed successively through thirteen center-hole-type furnaces at the National Tube Company's plant in Gary, Ind. The furnace units are arranged in line, like doughnuts in a box, about a foot apart. They burn gas premixed with air in special generators. Tube sections from 3 to 9 inches in diameter and with a maximum length of 45 feet pass through the 18-inch-diameter holes at rates up to 240 feet per minute and emerge at a lemon-yellow temperature of 1800°F. The picture shows one furnace in the line. An electric eye (left-center) controls the temperature in each section in accordance with the color of the tube.

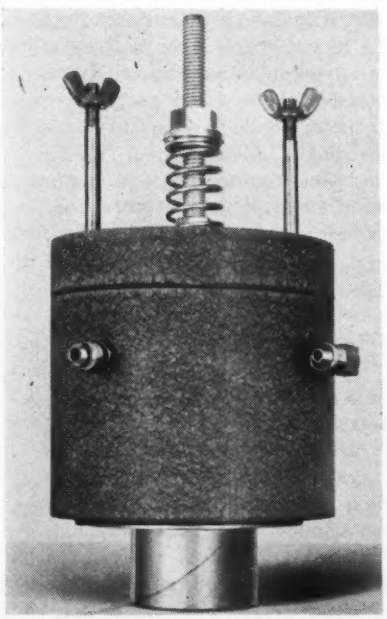
At the recent Folding Paper Box Association meeting, cartons made of a new packaging material developed by Robert Gair Company, Inc., received honorable mention. The paperboard, named Tuf-Bord, is said to resist tear, tensile-strength, and rigidity tests far beyond the customary folding-carton standards and offers opportunities for reductions in thickness and weight. It is suitable for packaging heavy products such as hardware, machine parts, books, and stationery supplies, as well as for glass and other fragile objects where stacking strength is desired. Tuf-Bord is available in four thicknesses; in white and colors; and its surface will take multicolor and high-gloss printing.

It is gratifying to learn that the use of beryllium-phosphor powder as a lining for fluorescent tubes is to be discontinued by Westinghouse, General Electric, and Sylvania on June 30 under an agreement with the U. S. Public Health Service. What the replacement substance will be has not been divulged, but it is safe to say that it will be harmless. For those who do not know that beryllium phosphor is poisonous, a word of caution is in order because many of the old tubes will still be in service. Burnt-out lamps should never be left where children may find them and play with them. They

should be broken under water for disposal, never in the open. Should a lamp break accidentally, leave the scene until the dust created has had a chance to settle. Handle the fragments with care because a cut by the glass, or powder entering a cut or wound, may have serious consequences.

Both a new sealing agent and a batch-immersion process have been developed by Western Sealant, Inc., for bonding dissimilar materials incorporated in parts that are designed to withstand extreme lateral or internal hydrostatic or aerostatic pressure. In addition to binding glass, neoprene, or plastic to metal, and ferrous to nonferrous metals, the method is said to eliminate microporosity by impregnating the work with the bonding agent, which has a wide range of resistance to operational temperatures and to chemical solvents. Further claims are that anodized, plated, and machined areas are not affected. The company is at present doing custom processing, but is making bench and large equipment available for general use.

The Baldwin Locomotive Works has added two low-range models to its line of Tate-Emery air cells. These new high-precision load-weighing devices may be used on testing machines for measuring the tensional and compressional strength of plastics, textiles, cord, paper, and other light materials, or they may be utilized independently for weighing chemicals or for controlling chemical processes. Each is 4½ inches in diameter, has a 2½-inch-diameter head for compression loading and a threaded extension for attaching fixtures for tension loading. The load is automatically balanced by air pressure through the action of a pneumatic force balance system controlled by an air jet and baffle inside the cell. The total movement of the load-



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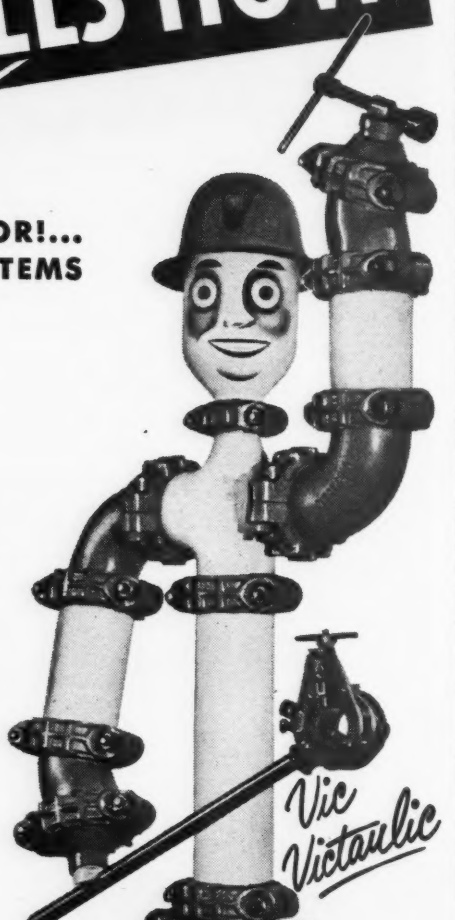

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sensitive member is less than 0.0005 inch and is transmitted to either a Tate-Emery or a Bourdon gauge-type indicator. The units have load ranges of 0-1.2 to 0-6 pounds and 0-2 to 0-10 pounds in tension and compression. The lowest capacity previously available was 0-30 pounds.

Neat's-foot oil is the basic ingredient of a new dressing for leather, canvas, and rubber belts. The liquid is made by Alexander Brothers and is said not to cake or gum but to penetrate the material and to provide a surface with a good grip. It is called Beltlube.

Krak-Stik is the trade name of a compound intended for the temporary repair of cracked drain lines, soil pipe, hot or cold water lines, etc. When rubbed over cracks and pinholes it is said to form a hard coat that will seal against low-pressure leakage. The stick is 4 inches long.

We've heard of pianos that sound metallic but never of one made of metal. Now comes word from Los Angeles, Calif., that the Key Action Corporation is engaged in the production of a portable 64-key instrument built of castings and parts stamped from ⅛-inch aluminum. It's to sell for $280. An 88-key spinet is to be introduced later at $350.

For keeping spray booths clean, the Northwest Chemical Company has announced a water-wash compound that lubricates the overspray. Identified as Northwest Number One, it coats each paint particle with a nonvolatile solvent that prevents it from sticking to the back curtain or eliminators. The booth is said to stay clean, the sludge remains afloat for easy skimming, and the operator works in clean, fresh air at all times.

Nodular graphite iron, a new development, attracted a great deal of attention at a recent convention of the American Foundrymen's Association. It is said to be superior to flake graphite iron in hardness, strength, ductility, and heat resistance. Also termed "ductile cast iron," one foundry is producing it at the rate of 50 tons a day. Several companies have applied for patents on the new material, but none has been granted up to date.

The American Standards Association is "taking some of its own medicine." Long a promoter of uniformity in industry to eliminate waste and to avoid confusion, the organization finds that American Standards have been published in some twenty different sizes by the various national coöperating groups. Henceforth they will conform to three dimensions: one for pamphlets, one for books, and a third for pocket-size books.

New Books and Industrial Literature

The Epic of American Industry, by James Blaine Walker, is the story of the growth of America's industrial wealth. It traces industry's rise from the time of the Jamestown Colony to the production achievements of World War II, a rise that has resulted in a country with less than 7 percent of the world's population but possessing one-third of its wealth.

The author—a former lawyer, manufacturing executive, investment banker, and member of the War Production Board in World War II—begins his book by describing the business system that existed in England at the time of the colonization of America. Following this, he deals with the economic and geographical conditions that prevailed in the new land and the forces that were present to bring about industrial development. Trade relationships with England before and after the revolution, the start of manufacturing in this country, the growth of foreign trading, and early adventures in business and banking of the fledgling nation are some of the subjects covered. The birth of the steel industry, the expansion of the railroads, and the winning of the West are reviewed, and their effects on the rising tide of industrialism explained. The movies, radio, aviation, and other representative American industries are similarly treated, and the relationship of government to banking and business is discussed.

According to the author, the fact that our people enjoy an abundance of the world's goods is due to their possession of political freedom. The book is therefore a strong affirmation of the benefits and potentialities of a free economic system. It is published by Harper Brothers, 49 East Thirty-third Street, New York 16, N. Y., price $5.00.

Rapid progress during the past decade in the generation of power by the direct action of combustible gases emphasizes the fact that this is a formative period in power-plant development. Gas turbines, rockets, ram jets, and other new types of power plants have created a demand for general thermodynamic procedures for making accurate analyses of their power cycles. In an effort to meet this need, H. C. Hottel, G. C. Williams, and C. N. Satterfield, all members of the faculty of Massachusetts Institute of Technology, have written a book published in two parts under the title *Thermodynamic Charts for Combustion Processes*. Part I explains the basis, method of development, and application of eight large charts that are in Part II and that deal with hydrocarbon fuels and air, as well as supplementary material. Part I contains several smaller generalized thermodynamic charts and also gives a number of examples to clarify the use of the charts and to illustrate the wide variety of problems that may be successfully handled.

In searching for the best combination of fuel and power cycle for each application, mapping of the thermodynamic characteristics to permit charting the course of any cycle using carbon, hydrogen, oxygen, and nitrogen in any proportion should be helpful. *Thermodynamic Charts for Combustion Processes*, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., attempts to give this assistance. Price $5: Part I, $2.60; Part II, $2.40.

The necessity of properly tempering cutting tools hardened in Hi-Speed-It, a new hardening compound in powder form produced by Wilson Carbon Company, Inc., is explained in a booklet obtainable from the

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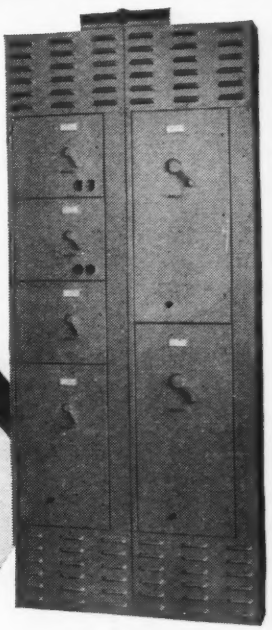

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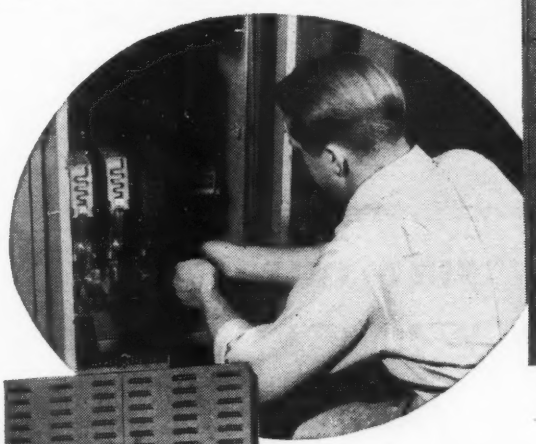

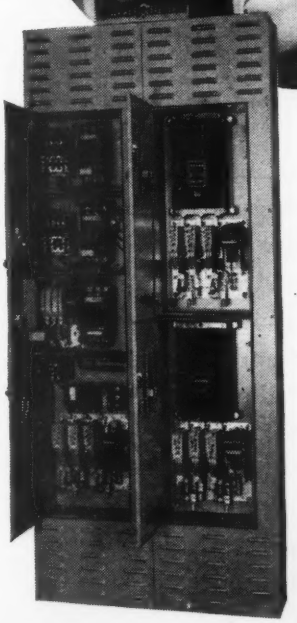

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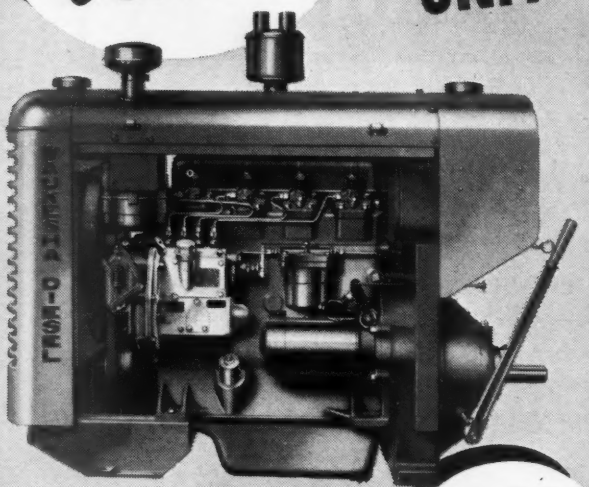

BULLETIN NO. 1410

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company at 60 East 42nd Street, New York 17, N. Y. Detailed instructions for hardening and tempering cold-rolled and machine steels and high-speed alloy steels are given. Also available is another booklet describing Hi-Speed-It and telling how it can be used to depth-harden steel tools, parts, etc., in a matter of minutes and with only simple equipment.

Technical Bulletin T-3 of The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y., deals with the resistance offered by high-nickel alloys to sulfuric-acid corrosion. Written primarily for industries in which the handling of this useful but highly corrosive agent presents a problem, it covers operations ranging from the pickling of steel to the processing of textiles. The bulletin contains 86 tables and 33 graphs that give the performances of more than 30 nickel-bearing materials in a wide variety of services.

Head guards that provide protection while not obstructing vision are described in Bulletin No. CN-2 of Mine Safety Appliances Company. Made of noninflammable vinyl plastic, the guards reach completely around the face, cover the ears, extend below the chin, and cover the entire forepart of the head. They protect the wearer from acids, chemicals, hot metal, sand, grit, grease, etc. Full details about them are contained in the publication, which may be obtained by writing to the company at Braddock, Thomas, & Meade Streets, Pittsburgh 8, Pa.

General Electric Company has prepared a series of five bulletins showing how electric heat, if properly applied, can help industry to increase output, provide better equipment designs, and improve product quality. They list the major uses of tubular-, strip-, and cartridge-type electric units in the heating of surfaces, pipe lines, process air and liquids, and the melting of soft metals. Heaters for each type of work are described, their operations discussed, and methods of calculating the necessary heater capacity are given. Copies of the bulletins will be sent upon request to the company at Schenectady 5, N. Y.

A 24-page bulletin on high-pressure condensate return systems is obtainable from Cochrane Corporation, Seventeenth & Allegheny Avenues, Philadelphia 32, Pa. They are available in sizes from 3 to 25 hp., and were developed by the company for the purpose of returning condensate from presses, driers, cookers, and similar steam-heated process equipment to boilers that are under higher pressures than the equipment they serve. Material and operation specifications are given both for the high-pressure and the standard-pressure systems manufactured by Cochrane. Dimensioned drawings in color show design and construction of the two types.

Electric Machinery Manufacturing Company, Minneapolis 13, Minn., will send upon request copies of two publications recently released by it. E-M Synchronizer No. 27 contains information helpful in the selection of generators, the paralleling of generators, the boosting of capacity to meet demands, and the application of "packaged" generators in industry. Booklet No. 4200-PRD-194 describes switchgear for both single and parallel generator installations at voltages from 120-5000. Construction features, specifications, and wiring diagrams are given for generator, synchronizing, feeder, and distribution panels, and installations in utility as well as industrial power stations likewise are illustrated and described.